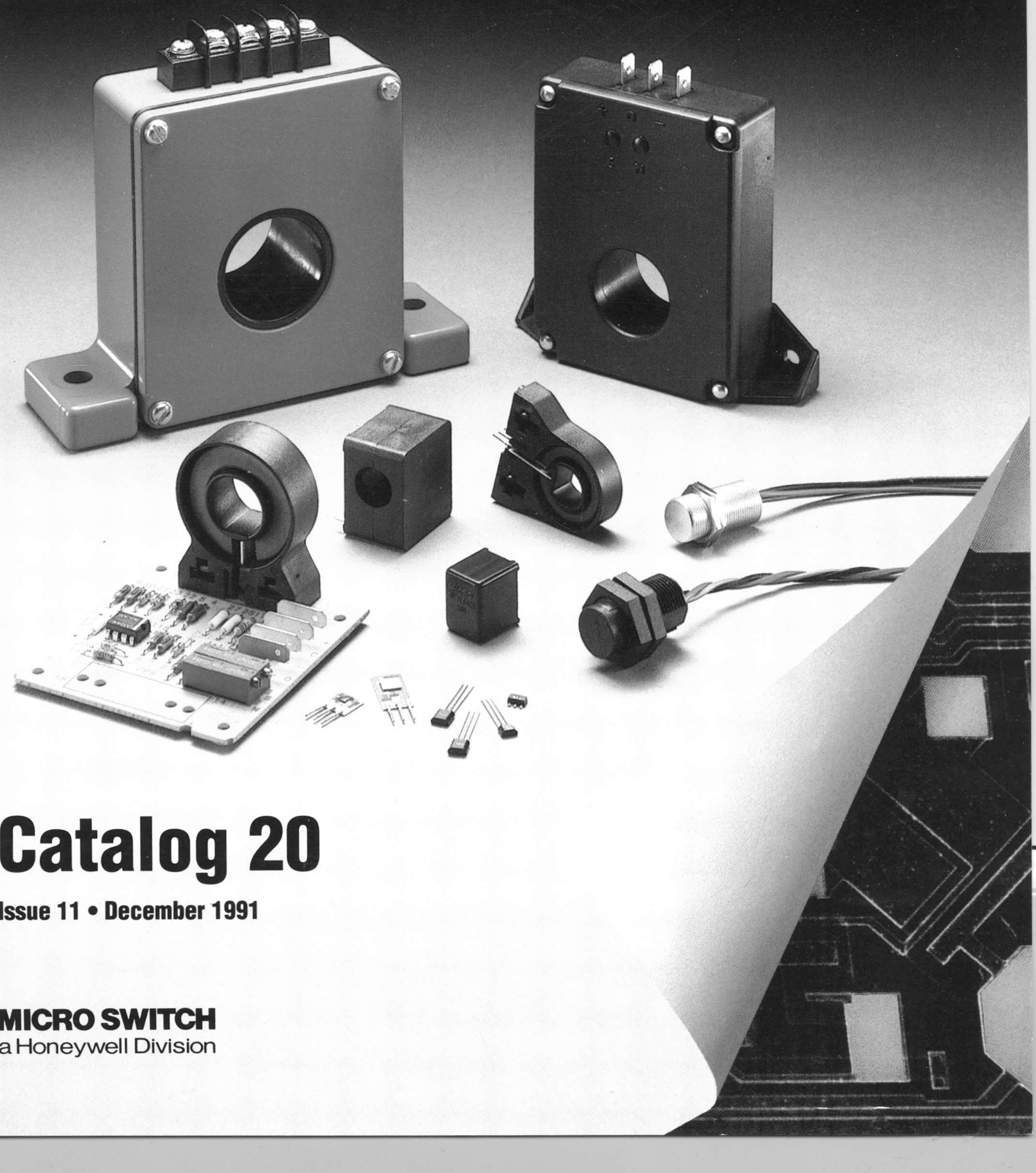
MICRO SWITCH
Specifier's Guide for Solid State Sensors

Hall Effect Position Sensors
Magnetoresistive Position Sensors
Current Sensors



Catalog 20

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MICRO SWITCH
a Honeywell Division

For unsurpassed reliability

MICRO SWITCH Solid State Sensors

Reliability. Speed. Long life. Compact size. Compatibility with microprocessors and other advanced electronic circuitry. But especially reliability. These features combine for cost-effective control when you use any of the various MICRO SWITCH solid state position, current or temperature sensors described in this specifier's guide.

With off-the-shelf availability and a wide choice of package styles and sizes you can benefit from cost-effective solid state sensing, regardless of the application. MICRO SWITCH factory-trained application engineers and dedicated field sales engineers will work with you to find the best solution for your sensing problems. If we can't provide the sensor you need off-the-shelf, chances are we can make it. MICRO SWITCH's customization capabilities are nearly infinite with extensive in-house test and evaluation lab and production capabilities. As a division of Honeywell, we work closely with other Honeywell Divisions in developing and processing integrated circuit chips for the most reliable solid state sensors you can buy. You have the assurance of getting the sensor you want when you want it from a nation-wide network of Authorized Distributors or directly from us. This commitment to quality and responsiveness has made MICRO SWITCH an industry leader for over 50 years.

POSITION SENSORS

Magnetically operated solid state position sensors are available in three distinct types: digital, analog, and integral magnet.

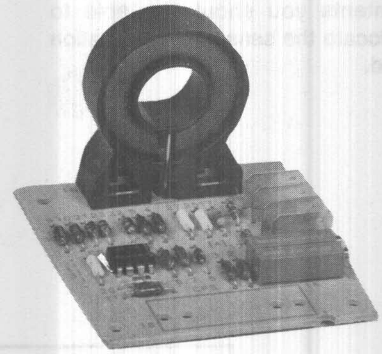
- SS4 is a three pin in-line molded plastic package for printed circuit board mounting with a single digital output.
- The SS2 and 2SSP series are ceramic substrate packages which are designed for printed circuit board mounting. They feature a single digital output and three pin in-line terminals, and extended sensing distances to 1 inch or more.
- The plastic housed SR3, 400SR, and aluminum housed 103SR feature a single digital output. A single adjustable analog output version of the 103SR is also available. The aluminum 103SR and plastic SR3 housings have color coded leadwires. The 400SR has solder/quick-connect terminals which accept standard push-on 110 connectors.
- The 9SS and SS9 are thin ceramic packages designed for printed circuit board mounting. They feature an analog output and three pin in-line terminals.
- XL and VX solid state switches combine mechanical switch operating and mounting convenience with solid state reliability. The VX series feature AMP or Molex plug-in connectors.

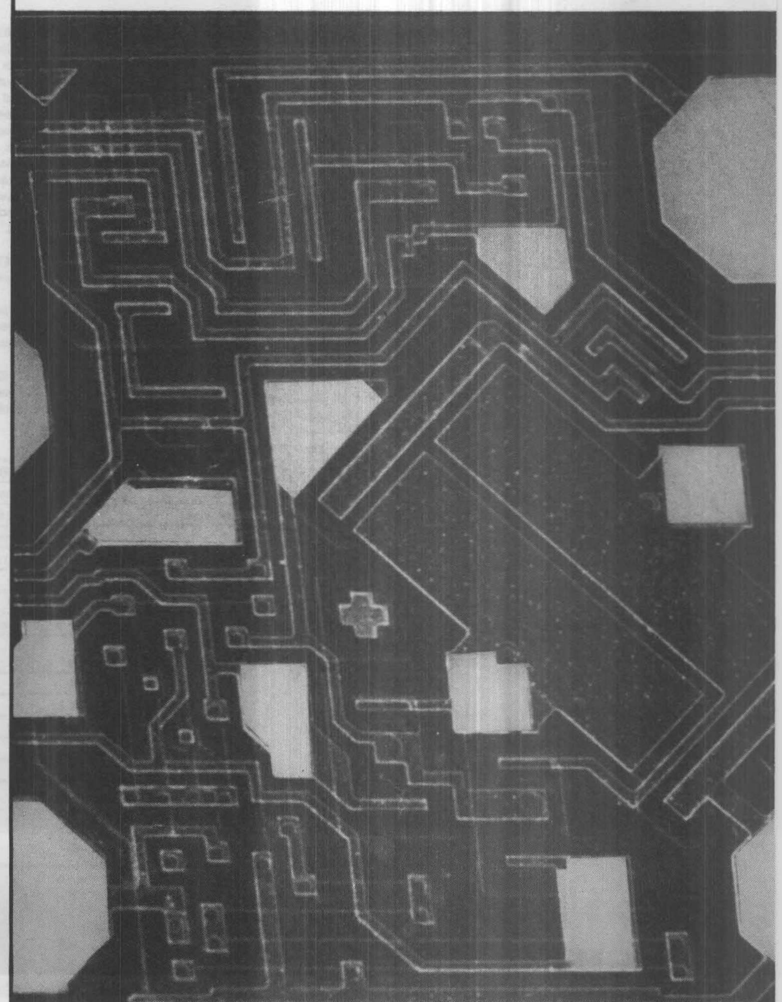
Several bar and ring magnets for actuating Hall effect sensors are available from MICRO SWITCH. Bar magnets, in various sizes and strengths, are ideal for sensors with unipolar magnetic characteristics. The ring magnets, with alternate South and North poles on the outside diameter, are especially useful for sensors with bipolar magnetic characteristics.

CURRENT SENSORS

Through-hole design current sensors monitor either alternating or direct current. This series includes a wide assortment of devices ranging from digital output current detectors capable of sensing a few hundred milliamps to linear sensors capable of monitoring several thousand amps. Current sensors provide a means of accurate, low-cost current sensing.

Table of Contents





MICRO SWITCH's customization capabilities are nearly infinite with extensive in-house test and evaluation lab and production capabilities.

Many current sensing applications use MICRO SWITCH solid state sensors, which utilize integrated circuitry, and provide long life.

MICRO SWITCH digital and analog current sensors are used in applications ranging from overload protection to energy management systems.

MICRO SWITCH Solid State Sensors

HOW TO USE THIS CATALOG
This catalog has been designed to help you make a logical choice in selecting the best solid state sensor for your particular application need. It allows a user familiar with MICRO SWITCH solid state sensors to quickly locate the exact page the information is on. For those unfamiliar with MICRO SWITCH sensors, a logical sequence is given to help you evaluate and select the best sensor for your application.

By taking a few minutes to familiarize yourself with the catalog organization and contents you should be able to quickly locate the sensor or information you need.

1. **Product Selection**
For those familiar with MICRO SWITCH sensors product selection will start with the Table of Contents on page 3. If the user is not familiar with the device, product selection should begin with the Selection Guide on page 6. Here photos for each sensor and important parameters are given to help determine and select the best sensor for the application. By evaluating and comparing these parameters a logical selection may be made.

2. **Product Specifications and Ordering Information**
Once a solid state sensor is selected from the table of contents or selection guide, you are ready to look at individual product specifications.

This specifier's guide is divided into three product sections: position sensors, current sensors and temperature sensors. Position sensors are subdivided into four groups: digital, analog, integral magnet and magnets. Each product section provides background information on Features, Operation and Application. In addition, the position sensor section is introduced with General Information on each group.

Individual product specifications begin with a photo **(A)** of the product. Unique features **(B)** of that product are highlighted. The order guide includes catalog listings **(C)** which appear across the top or on the left of the order guide; all product specifications **(D)** important to your application appear on the left or across the top of the order guide; and sensor characteristics **(E)** appear below or at the right of the catalog listings. Finally, mounting dimensions **(F)** are given for all products.

2SSP Digital position sensors

A

B

FEATURES
- *Low gauss operation can extend sensing distance to one inch or more, depending on magnet size*
- *Digital current sinking output*
- *Omnipolar – can be operated with either North or South magnetic pole*
- *Operating speed: 0 to over 100 kHz*
- *Small size: .18 x .18 inch*
- *3-pin, in-line PC board terminals on .100-inch mounting centers*
- *Operating temperature range: – 20° to 85°C (– 4° to 185°F)*

OPERATION
2SSP Series position sensors have magnetoresistive material integrated on silicon and encapsulated in a plastic package. The integrated circuit provides a digital output in response to very low magnetic fields. Though this signal is idential to our digital Hall effect sensors, it can be achieved by magnetoresistive sensors at much greater sensor-to-magnet distances. For example, the 2SSP sensing distance is approximately one inch, when operated by a MICRO SWITCH 101MG3 magnet.

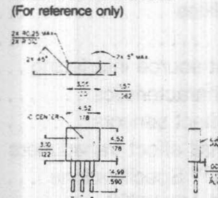
OPERATING MODE
(Arrows indicate direction of magnetic flux.)

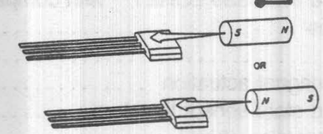
2SSP sensors are operated by magnetic fields (North or South pole) **parallel** to the magnetoresistive element.

NOTE: Due to the inherent high sensitivity of 2SSP sensors, stray magnetic fields which are parallel to the IC may affect operation.

MOUNTING DIMENSIONS
(For reference only)

F





C, D, E

2SSP ORDER GUIDE

Catalog Listings			**2SSP**
Supply Voltage (VDC)			6 to 24
Supply Current (mA max.)			13.5
Output Type			Sink
Output Voltage (V)			.40 max.
Output Current (mA max.)			20
Leakage Current (µA max.)			10
Magnetics Type			Omnipolar
Magnetic Gauss Char. & Temp.	– 20 to 85°C	Max. Op.	25
		Min. Rel.	8
		Max. Dif.	7
	25°C Typ.	Typ. Op.	15
		Typ. Rel.	11
		Typ. Dif.	4

3. **Need Maximum Rating Information? — Page 42**
Absolute maximum rating charts for position and temperature sensors are included.

4. **Need Additional Solid State Sensors? — Page 44**
Solid state sensors other than those shown in this specifier's guide are highlighted. They include airflow and pressure.

5. **Interested in Advanced Sensing Capabilities? — Page 45**
New sensor technologies that broaden even further MICRO SWITCH's capabilities are featured.

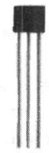
6. **Need Application Help? — Page 46**
This section includes information on interpreting operating characteristics, interfacing and applying solid state sensors. A list of additional available solid state sensor literature and a magnetic conversion chart follow. Remember, application assistance is also readily available from our nearby sales office.

7. **Need Operating Characteristics and Terminology Explained? — Page 72**
Definitions of operating characteristics and terms will familiarize you with terminology used throughout the specifier's guide.

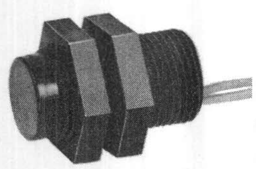
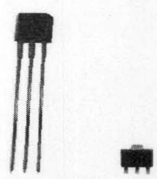
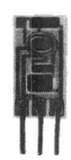
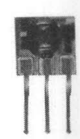
8. **Need Other MICRO SWITCH Products? — Page 73**
Other MICRO SWITCH products including comprehensive product catalogs 10 through 80 and their contents are referenced.

Solid state sensor selection guide

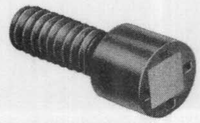
POSITION SENSORS

		
2SSP **Page 10**	**SS2** **Page 11**	**SS400** **Page 12**

	2SSP	SS2	SS400
Operation	Proximity to external magnet	Proximity to external magnet	Proximity to external magnet
Supply Voltage	6-24 VDC	4.5 - 5.5 VDC and 6-24 VDC	3.8 to 24 VDC
Construction	Molded plastic package	Ceramic hybrid circuit	Molded plastic package
Termination	Printed circuit board	Printed circuit board	Printed circuit board
Operating Speed	0 to over 100 kHz	0 to 100 kHz	0 to over 100 kHz
Temperature Range	−20 to 85°C	−20 to 85°C	−40 to 150°C
Output Type	Digital, current sink	Digital, current sink	Digital, current sink

		 
SR3 **Page 18**	**SS49/SS19** **Page 20**	**9SS/SS89** **Page 21**

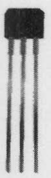
	SR3	SS49/SS19	9SS/SS89
Operation	Proximity to external magnet	Proximity to external magnet	Proximity to external magnet
Supply Voltage	4.5-24 VDC	4-10 VDC	8-16 VDC and 5.4-13.2 VDC
Construction	Thermoplastic housing	Molded plastic	Ceramic hybrid circuit
Termination	Leadwires	Printed circuit board (surface mount)	Printed circuit board
Operating Speed	0 to over 100 kHz	1.5 μ seconds (Response Time)	3 μ seconds (Response Time)
Temperature Range	−40 to 85°C	−55 to 150°C (SS49) −40 to 125°C (SS19)	−40 to 150°C (9SS) −20 to 85°C (SS89)
Output Type	Digital, current sink	Analog, current source	Analog, current source (9SS) Analog, current sink or source (SS89)

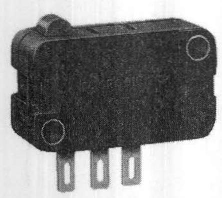
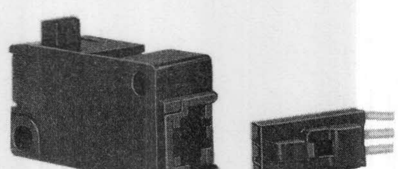
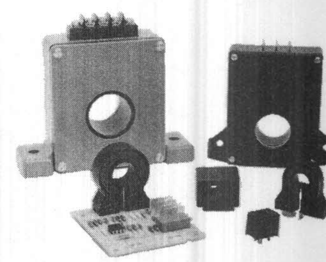


MICRO SWITCH supplies bar and ring magnets for operating our Hall effect sensors. These are provided in a wide variety of magnetic materials, sizes, shapes, and mounting options.

MG MAGNETS
Page 30

Solid state sensor selection guide

			
SS41 **Page 14**	**SS1** **Page 15**	**103SR** **Page 16**	**400SR** **Page 17**
Proximity to external magnet	Proximity to external magnet	Proximity to external magnet	Proximity to external magnet
4.5 to 24 VDC	4.5 to 24 VDC	4.5-5.5 VDC and 6-24 VDC	6-24 VDC
Molded plastic	Molded plastic	Threaded aluminum housing	Molded plastic housing (Can be gang mounted)
Printed circuit board	Printed circuit board (Surface mount)	Leadwires	Solder/quick-connect
0 to over 100 kHz	0 to over 100 kHz	0 to over 100 kHz	0 to over 100 kHz
−55 to 150°C	−40 to 125°C	−40 to 100°C	−40 to 150°C
Digital current sink	Digital current sink	Digital current sink or source Analog current source	Digital, current sink

	SOLID STATE BASIC SWITCH		CURRENT SENSORS
			
SS94 **Page 22**	**XL** **Page 25**	**VX** **Page 27**	**CS** **Page 31**
Proximity to external magnet	Mechanical plunger	Mechanical plunger	Current sensor
4.5-12 VDC, 6.6-12 VDC	4.5-5.5 VDC and 6-24 VDC	4.5 to 24 VDC	Depends on sensor
Ceramic hybrid circuit	Plastic housing	Plastic housing	Plastic housing
Printed circuit board	Solder/quick-connect	Connector compatible	Screw, quick-connect or printed circuit board
3 μ seconds (Response Time)	Depends on actuator	Depends on actuator	Depends on sensor
−40 to 125°C	−40 to 100°C	−40 to 70°C	−25 to +85°C
Analog, current source or sink	Digital, current sink normally OFF or normally ON	Digital, current sink normally OFF or normally ON	Analog or digital

Our solid state sensor products are not necessarily designed or manufactured for use as a "critical component" in a "critical device" as those terms are defined in the Medical Devices Subchapter contained in the Food & Drug Administration Rules, 21CFR 800.

Position sensors

FEATURES

- *Magnetic sensing using Hall effect technology*
- *4.5 to 24 volt supply voltages*
- *Wide variety of package sizes*
- *Sensor only and combination magnet/sensor units*
- *Digital and analog outputs*
- *Solid state reliability*

OPERATION

MICRO SWITCH solid state Hall effect position sensors produce either a digital or analog output. Digital output sensors are in one of two states — on or off. Analog sensors provide a continuous voltage output which increases with a strong magnetic field and decreases with a weak magnetic field.

There are three types of digital sensors, bipolar, omnipolar and unipolar. Bipolar sensors require positive gauss (south pole) to operate and negative gauss (north pole) to release. Omnipolar sensors operate with either the north or the south pole. Unipolar sensors require a single magnetic pole (south) to operate. Release is obtained by moving the south pole away from the sensor. Analog sensors operate by proximity to either magnetic pole. Digital and analog sensor only devices are operated by the magnetic field from a permanent magnet or an electromagnet. Actuation mode depends on the type of magnets used. Integral magnet supplied position sensors are mechanically operated by a magnet mounted on a plastic plunger.

For further information on digital sensors see page 10, analog page 20, or integral magnet page 25.

APPLICATION

Typical sensor applications include:

- Ignition timing
- Power sensing
- Valve position
- Robotics control
- Current sensing
- Linear or rotary motion detection
- Length measurement
- Flow sensing
- RPM sensing
- Security systems

Sensors are used in:

- Brushless DC motors
- Utility meters
- Water softeners
- Gasoline pumps
- Welding equipment
- Balance scales
- Interlocks
- Flowmeters
- Magnetic card readers
- Vending machines
- Home appliances
- Computer equipment
- Medical instruments
- Copy machines
- Laboratory equipment

Digital position sensors

GENERAL INFORMATION
Digital position sensors are available in a variety of packages. SS4 series are available in a molded plastic housing. The SS2 series are ceramic substrate packages. The 103SR and SR3 series feature threaded, cylindrical housings. The 400SR is a rectangular plastic housing.

- 2SS and SS4 are 3 pin in-line plastic packages for printed circuit board mounting with a single output.
- SS2 is a thin ceramic package designed for printed circuit board mounting, featuring a single output and 3 pin in-line terminals with an extended sensing distance.
- SS1 is a 3 pin plastic package for surface-mount assembly. It is identical to the industry standard SOT-89 package.
- SR position sensors feature single output and environmentally protected housings. The aluminum 103SR and plastic SR3 housings have color coded leadwires. The 400SR has solder/quick-connect terminals which accept standard push-on 110 connectors.

DEFINITIONS
Current Sinking (NPN) — A transistor configuration where loads are normally connected between the output and a supply voltage. When the transistor is ON current flow is from the load into the transistor.

Current Sourcing (PNP) — A transistor configuration where loads are normally connected between the output and ground. When the transistor is ON current flow is from the transistor into the load.

Differential (Hall effect transducer) — The difference between the operate and release values of a Hall effect transducer.

Maximum Operate Point refers to the level of magnetic field which will insure the digital output transducer turns ON under any rated condition.

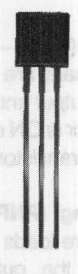
Minimum Release Point refers to the level of magnetic field that insures the transducer is turned OFF.

Magnetic gauss values are found in each order guide.

For magnet ordering information see page 31.

For absolute maximum ratings, see pages 42 and 43.

2SSP Digital position sensors



FEATURES

- *Low gauss operation can extend sensing distance to one inch or more, depending on magnet size*
- *Digital current sinking output*
- *Omnipolar – can be operated with either North or South magnetic pole*
- *Operating speed: 0 to over 100 kHz*
- *Small size: .18 x .18 inch*
- *3-pin, in-line PC board terminals on .100-inch mounting centers*
- *Operating temperature range: – 20° to 85°C (– 4° to 185°F)*

OPERATION

2SSP Series position sensors have magnetoresistive material integrated on silicon and encapsulated in a plastic package. The integrated circuit provides a digital output in response to very low magnetic fields. Though this signal is idential to our digital Hall effect sensors, it can be achieved by magnetoresistive sensors at much greater sensor-to-magnet distances. For example, the 2SSP sensing distance is approximately one inch, when operated by a MICRO SWITCH 101MG3 magnet.

OPERATING MODE

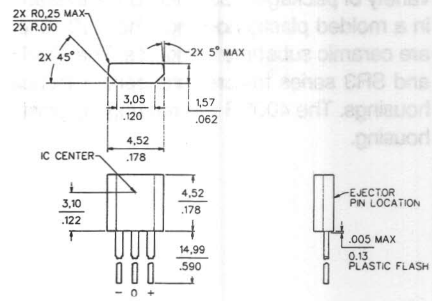
(Arrows indicate direction of magnetic flux.)

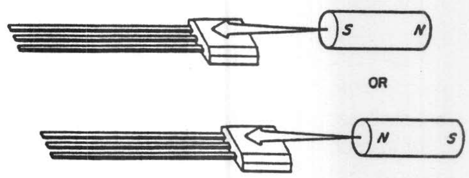
2SSP sensors are operated by magnetic fields (North **or** South pole) **parallel** to the magnetoresistive element.

NOTE: Due to the inherent high sensitivity of 2SSP sensors, stray magnetic fields which are parallel to the IC may affect operation.

MOUNTING DIMENSIONS

(For reference only)

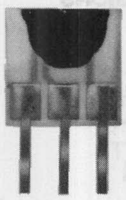




2SSP ORDER GUIDE

Catalog Listings		2SSP
Supply Voltage (VDC)		6 to 24
Supply Current (mA max.)		13.5
Output Type		Sink
Output Voltage (V)		.40 max.
Output Current (mA max.)		20
Leakage Current (µA max.)		10
Magnetics Type		Omnipolar
Magnetic Gauss Char. & Temp.		
– 20 to 85°C	Max. Op.	25
	Min. Rel.	8
	Max. Dif.	7
25°C Typ.	Typ. Op.	15
	Typ. Rel.	11
	Typ. Dif.	4

Digital position sensors SS2



FEATURES

- *Low gauss operation can extend sensing distance to one inch or more, depending on magnet size*
- *Digital current sinking output*
- *Omnipolar—can be operated with either North or South magnetic pole*
- *Operating speed: 0 to over 100 kHz*
- *Small size: .3 × .3 inch (with epoxy chip protection)*
- *3-pin, in-line PC board terminals on .100-inch mounting centers*
- *Operating temperature range: −20° to 85°C (−4° to 185°F)*

OPERATION

SS2 Series position sensors have magnetoresistive material integrated on silicon and protected by an epoxy overcoat. The integrated circuit provides a digital output in response to very low magnetic fields. Though this signal is identical to our digital Hall effect sensors, it can be achieved by magnetoresistive sensors at much greater sensor-to-magnet distances. For example, the SS2 sensing distance is approximately one inch, when operated by a MICRO SWITCH 101MG3 magnet.

OPERATING MODE

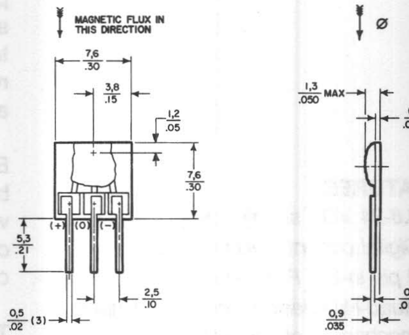
(Arrows indicate direction of magnetic flux)

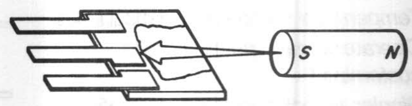
SS2 sensors are operated by magnetic fields (North **or** South pole) **parallel** to the magnetoresistive element.

NOTE: Due to the inherent high sensitivity of SS2 sensors, stray magnetic fields which are parallel to the IC may affect operation.

MOUNTING DIMENSIONS

(For reference only)





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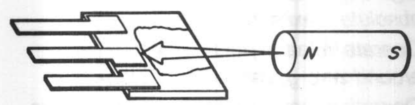
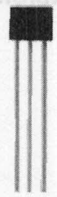


SS2 ORDER GUIDE

Catalog Listings			SS21PE	SS22PE
Supply Voltage (VDC)			4.5 to 5.5	6 to 24
Supply Current (mA max.)			10	13.5
Output Type			Sink	Sink
Output Voltage (V)			.40 max.	.40 max.
Output Current (mA max.)			20	20
Leakage Current (μA max.)			10	10
Magnetics Type			Omnipolar	Omnipolar
Magnetic Gauss Char. & Temp.				
	−20 to 85°C	Max. Op.	25	25
		Min. Rel.	5	5
		Min. Dif.	2	2
	25°C Typ.	Typ. Op.	15	15
		Typ. Rel.	11	11
		Typ. Dif.	4	4

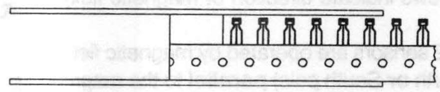
SS400 Digital position sensors



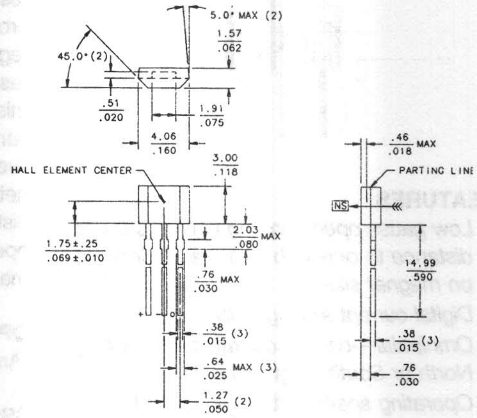
400SS Series position sensors have a thermally balanced ingrated circuit over full temperature range. The negative compensation slope is optimized to match the negative temperature coefficient of lower cost magnets. Bipolar, latching and unipolar magnetics are available.

Band gap regulation provides extremely stable operation over 3.8 to 24 VDC supply voltage range. SS400 sensors are capable of continuous 20 mA sinking output, and may be cycled as high as 50 mA maximum.

TAPE AND REEL



MOUNTING DIMENSIONS
(For reference only)



FEATURES

- *3.8-24 VDC supply voltage*
- *Digital current sinking output*
- *3 pin in-line PCB terminals*
- *Quad-Hall design virtually eliminates mechanical stress effects*
- *Temperature compensated magnetics*
- *Operate/release points can be customized*
- *Bipolar, unipolar, latching magnetics*
- *High output current capability – 50 mA absolute maximum*
- *Operate/release points symmetrical around zero gauss (bipolar/latch)*
- *Operating temperature range of −55 to +150°C (−67 to +302°F)*

ORDER GUIDE

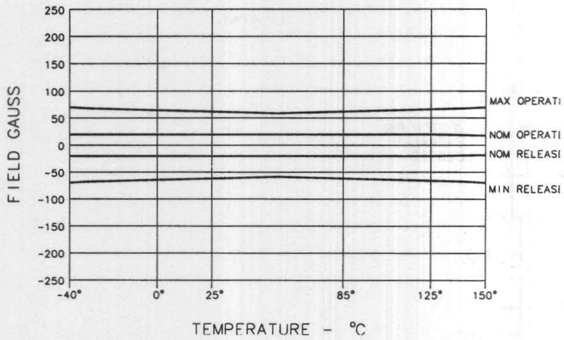
Catalog Listing		SS411A	SS413A	SS441A	SS443A	SS449A	SS461A	SS466A
Magnetic Type		Bipolar	Bipolar	Unipolar	Unipolar	Unipolar	Latching	Latching
Supply Voltage (VDC)		3.8 to 24	3.8 to 24	3.8 to 24	3.8 to 24	3.8 to 24	3.8 to 24	3.8 to 24
Supply Current (max.)		10 mA	10 mA	10 mA	10 mA	10 mA	10 mA	10 mA
Output Type		Sink	Sink	Sink	Sink	Sink	Sink	Sink
Output Voltage (max.)		.40 V	.40 V	.40 V	.40 V	.40 V	.40 V	.40 V
Output Current, max.*		20 mA	20 mA	20 mA	20 mA	20 mA	20 mA	20 mA
Output Leakage Current, max.		10 μA	10 μA	10 μA	10 μA	10 μA	10 μA	10 μA
Output Switching Time								
V_{CC}=12 V, R_L=1.6 K, C=20 pF	Rise (10-90%)	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.	.05 μs typ. 1.5 μs max.
	Fall (90-10%)	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.	.15 μs typ. 1.5 μs max.
Magnetic Characteristics (Gauss)								
−40°C	Max. Op.	70	140	135	215	435	110	200
	Min. Rel.	−70	−140	20	80	210	−110	−200
	Min. Dif.	15	20	15	25	30	50	200
0°C	Max. Op.	65	140	117	190	400	90	185
	Min. Rel.	−65	−140	20	80	230	−90	−185
	Min. Dif.	15	20	18	25	30	50	200
25°C	Max. Op.	60	140	115	180	380	85	180
	Min. Rel.	−60	−140	20	75	245	−85	−180
	Min. Dif.	15	20	20	25	30	50	200
85°C	Max. Op.	60	140	120	180	400	85	180
	Min. Rel.	−60	−140	15	70	215	−85	−180
	Min. Dif.	12	20	15	15	30	50	190
125°C	Max. Op.	65	140	123	190	410	100	180
	Min. Rel.	−65	−140	15	60	200	−100	−180
	Min. Dif.	12	20	8	10	30	50	160
150°C	Max. Op.	70	140	125	200	420	110	185
	Min. Rel.	−70	−140	10	55	185	−110	−185
	Min. Dif.	10	20	5	5	30	50	140

* Absolute maximum output current is 50 mA for all SS400 listings.

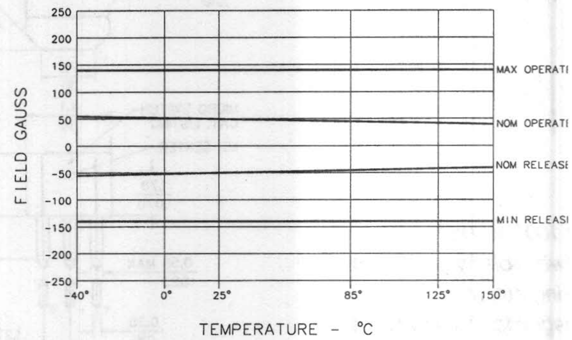
Note: For SS400 on tape and reel with formed leads on 0.100″ centers, contact your nearest MICRO SWITCH Sales Office. One reel contains 3,000 sensors.

OPERATE AND RELEASE POINTS

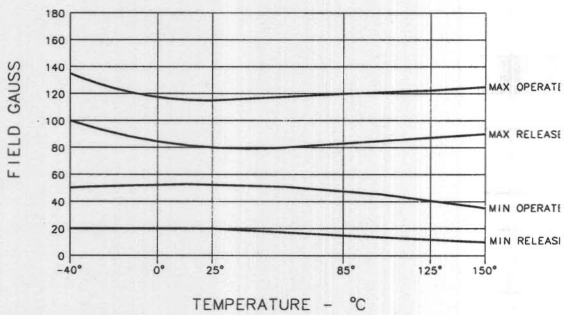
SS411A



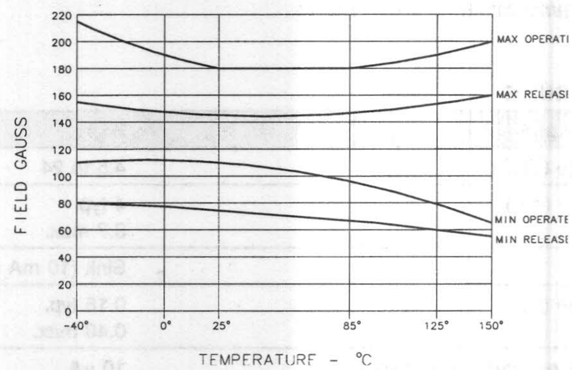
SS413A



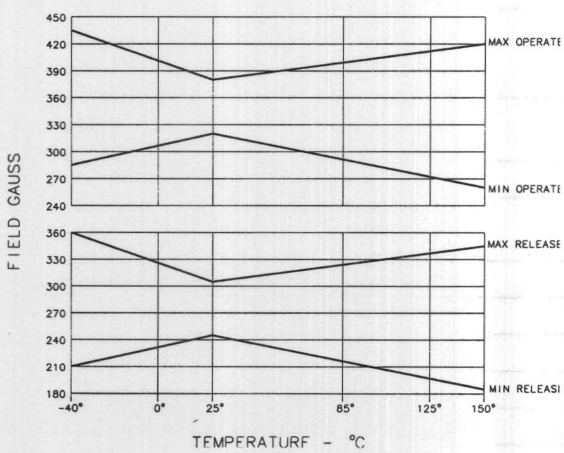
SS441A



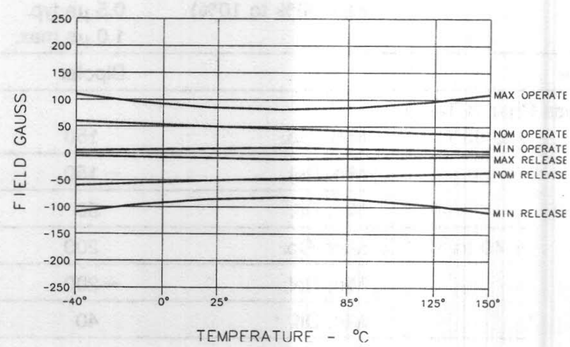
SS443A



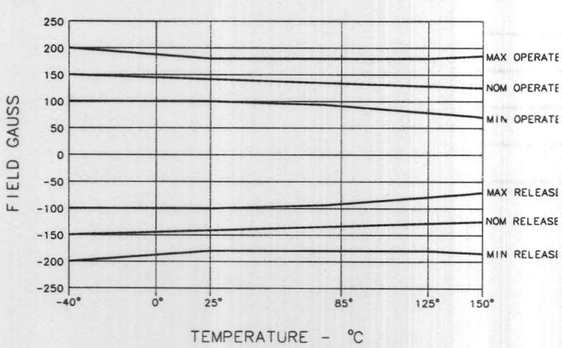
SS449A



SS461A

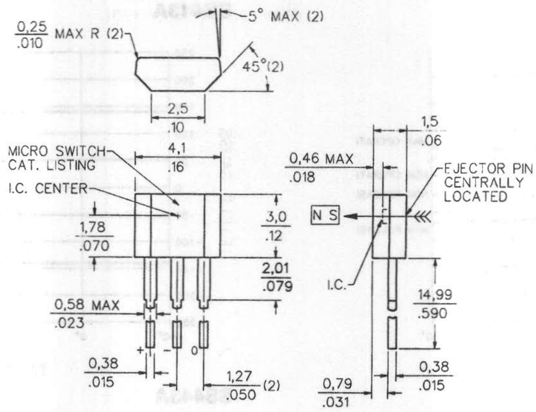


SS466A



SS41 Digital bipolar position sensors

MOUNTING DIMENSIONS (For reference only)



FEATURES

- *Small size (.160" x .118")*
- *Reverse power polarity protection*
- *Current sinking output*
- *Sensitive magnetic characteristics*
- *Operating speed from 0 to over 100 kHz*
- *Operating temperature range: −55° to 150°C*

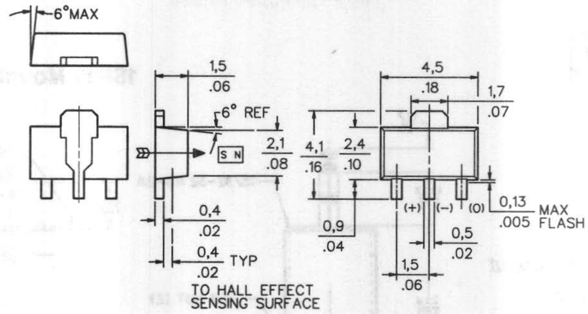
8SS ORDER GUIDE

Catalog Listings			SS41
Supply Voltage (VDC)			4.5 to 24
Supply Current (mA)			4 typ. 8.7 max.
Output Type			Sink (10 mA max.)
Output Voltage (V)			0.15 typ. 0.40 max.
Output Leakage Current (Released)			10 μA Leakage into sensor
Output Switching Time		Rise (10% to 90%)	0.2 μs typ. 1.5 μs max.
		Fall (90% to 10%)	0.5 μs typ. 1.0 μs max.
Magnetic Type			Bipolar
Magnetic Gauss Char. & Temp.	0 to 85°C	Max. Op.	150
		Min. Rel.	−150
		Min. Dif.	50
	−40 to 125°C	Max. Op.	200
		Min. Rel.	−200
		Min. Dif.	40
	25°C Typ.	Typ. Op.	40
		Typ. Rel.	−40
		Typ. Dif.	80
	−55 to 150°C	Max. Op.	250
		Min. Rel.	−250
		Min. Dif.	30

FEATURES

- *Small-size SOT89 style package (.177 × .136 × .059 in.) surface mounts on PC boards and flexible circuits*
- *Available in bulk or on tape and reel*
- *Reverse polarity protection*
- *Current sinking output*
- *Sensitive magnetic characteristics*
- *Compatible with pick-and-place equipment for automated assembly operations*
- *Operating speed: 0 to over 100 kHz*

MOUNTING DIMENSIONS (For reference only)



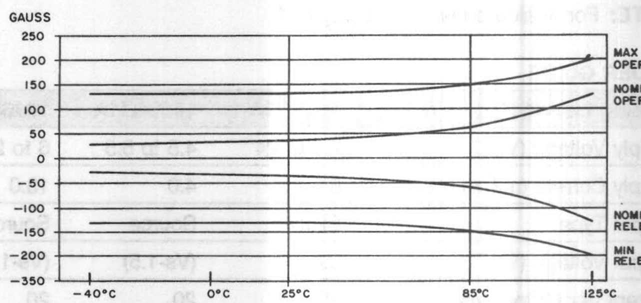
ORDER GUIDE (Add "T" suffix to catalog listing for tape and reel as shown below.)

Catalog Listings	SS11 (SS11T)
Magnetic Type	Bipolar
Supply Voltage (VDC)	4.5 to 24
Supply Current (mA)	4 typ. 8.7 max.
Sinking Output (mA)	10 max.
Output Voltage (V)	0.15 typ. 0.40 max.
Output Leakage Current, Released (µA) (Leakage into sensor)	10
Output Switching Time (µs) Rise (10% to 90%)	0.2 typ. 1.5 max.
Fall (90% to 10%)	0.5 typ. 1.0 max.
Magnetic Characteristics (Gauss) @ 0 to 85°C, 32 to 185°F	
Max. Operate	150
Min. Release	–150
Min. Differential	50
@ –40 to 125°C, –40 to 257°F	
Max. Operate	200
Min. Release	–200
Min. Differential	40
@ 25°C, 77°F typ.	
Typ. Operate	40
Typ. Release	–40
Typ. Differential	80

APPLICATION INFORMATION

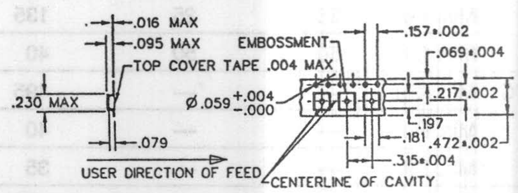
Operate/Release Characteristics Shift Over Temperature

SS11 Operate and Release vs. Temperature

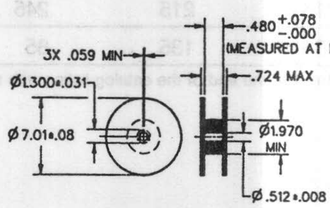


TAPE AND REEL DIMENSIONS

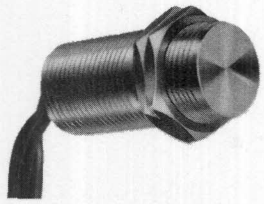
Tape



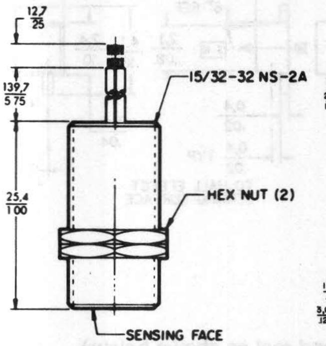
Reel



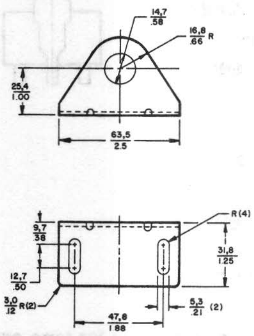
103SR Digital position sensors



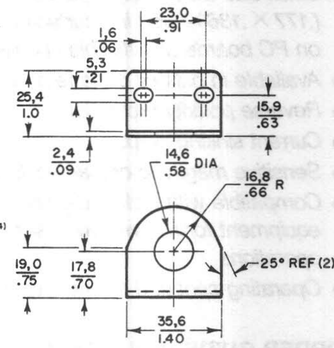
MOUNTING DIMENSIONS (For reference only)



1SR15 Mounting Bracket



1SR15HD Mounting Bracket



FEATURES

- *Current sinking or current sourcing ouput*
- *Rugged, sealed threaded aluminum housing NEMA 3, 3R, 3S, 4, 12 and 13 requirements**
- *20 gauge, 6 inch stranded leadwires, color coded and teflon insulated or 1 meter jacketed cable*
- *Adjustable mounting*
- * Stainless steel housing available for applications requiring compliance to NEMA 4X. Contact MICRO SWITCH sales office.

Leadwire color code:

Red	Vs (+)
Black	Ground (−)
Blue, Green, or White	Output

NOTE: For analog sensors, see page 24.

ORDER GUIDE

Catalog Listings*		103SR5A-1	103SR11A-1	103SR12A-1	103SR13A-1	103SR17A-1	103SR18-1	103SR15A-10
Supply Voltage (VDC)		4.5 to 24	4.5 to 5.5	6 to 24	4.5 to 24	4.5 to 24	4.5 to 24	4.5 to 24
Supply Current (mA max.)		8.0	4.0	13.0	10.0	10.0	8.7 mA	22 mA
Output Type		Sink	Source	Source	Sink	Sink	Sink	Sink
Output Voltage (V)		0.4	(Vs-1.5)	(Vs-1.5)	0.4	0.4	0.4	0.4
Current per Output (mA)		20	20	20	20	20	10	20
Magnetics Type		Unipolar	Unipolar	Unipolar	Unipolar	Bipolar	Latching	Unipolar
Magnetic Gauss Char. & Temp.								
0 to 70°C	Max. Op.	735	735	475	475	180	—	
	Min. Rel.	25	25	135	135	− 180	—	
	Min. Dif.	50	50	40	40	40	—	
− 40 to 100°C	Max. Op.	—	—	495	495	180	80	400
	Min. Rel.	—	—	40	40	− 180	− 80	200
	Min. Dif.	—	—	35	35	160	40	50
25°C Typ.	Typ. Op.	350	350	330	330	50	40	350
	Typ. Rel.	215	215	245	245	− 50	− 40	275
	Typ. Dif.	135	135	85	85	100	80	75

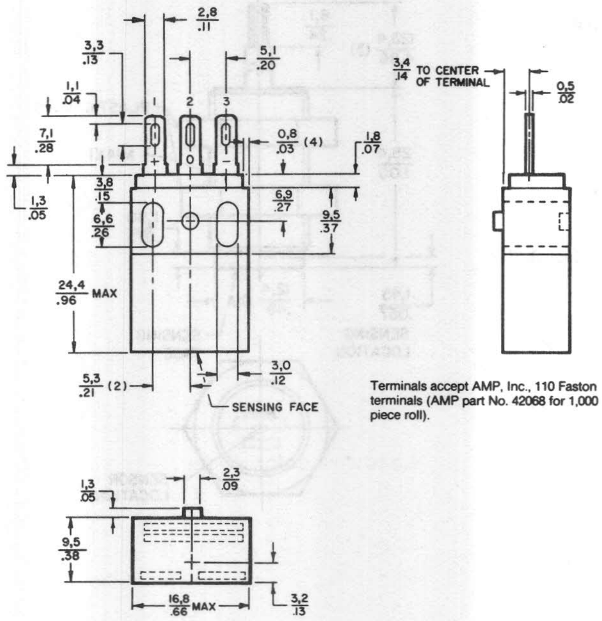
* To order 1 meter jacketed leads, replace the 1 at the end of the catalog listing with a 2. Example 103SR5A-2.

Digital position sensors 400SR

FEATURES

- *Current sinking output*
- *Rugged thermoplastic housing*
- *Locating boss on each package and corresponding indentation on other side for gang mounting*
- *Elongated mounting holes for adjustable screw mounting*
- *Solder/quick-connect terminals accept standard push-on 110 connectors*
- *0 to over 100 kHz operating speed*

MOUNTING DIMENSIONS (For reference only)



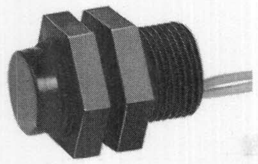
Terminals accept AMP, Inc., 110 Faston terminals (AMP part No. 42068 for 1,000 piece roll).

400SR ORDER GUIDE

Catalog Listings			413SR10	417SR10	413SR13	413SR15	417SR11
Supply Voltage (VDC)			6 to 16	6 to 16	4.5 to 24	4.5 to 24	4.5 to 24
Supply Current (mA max.)			10.0	10.0	18	22	8.7
Output Type			Sink	Sink	Sink	Sink	Sink
Output Voltage (V)			0.4	0.4	0.4	0.4	0.4
Current per Output (mA)			20	20	10	20	10
Magnetics Type			Unipolar	Bipolar*	Unipolar	Unipolar	Bipolar
Magnetic Gauss Char. & Temp.							
	0 to 70°C	Max. Op.	560	200	180	375	80
		Min. Rel.	185	−200	90	220	−80
		Min. Dif.	40	40	10	50	40
	−40 to 100°C	Max. Op.	580	220	220	400	100
		Min. Rel.	150	−220	60	200	−100
		Min. Dif.	40	40	10	50	40
	−40 to 150°C	Max. Op.	600	250	240	430	130
		Min. Rel.	50	−250	40	160	−130
		Min. Dif.	40	40	10	50	40
	25°C Typ.	Typ. Op.	400	120	150	350	40
		Typ. Rel.	300	−120	100	280	−40
		Typ. Dif.	100	120	30	70	80

* Not necessarily latching.

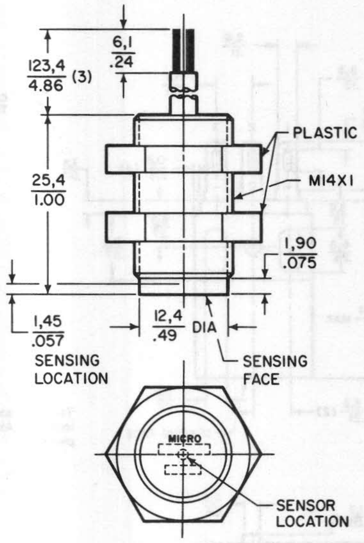
SR3 Digital position sensors



FEATURES

- *Completely enclosed housing*
- *Color coded leadwires*
- *High speed, no-touch operation over 100 kHz possible*
- *Adjustable mounting*
- *Reverse polarity protection (bipolar listing)*
- *Meets NEMA 3, 3R, 3S, 4, 4X, 12 and 13 requirements*

MOUNTING DIMENSIONS (For reference only)

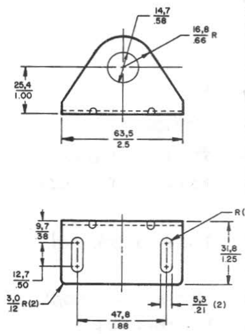


Leadwire color code:

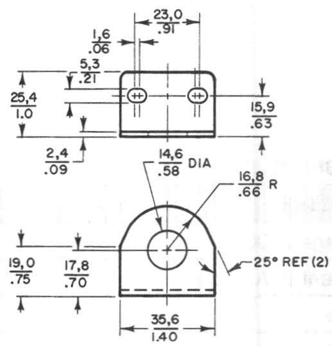
Red	Vs (+)
Green	Output
Black	Ground (−)

MOUNTING BRACKETS

1SR14M



1SR14MHD



SR3 ORDER GUIDE

Catalog Listings			SR3F-A1	SR3B-A1	SR3C-A1	SR3G-A1
Supply Voltage (VDC)			4.5 to 24	4.5 to 24	4.5 to 24	4.5 to 24
Supply Current (mA max.)			18.0	8.7	18	22
Output Type			Sink	Sink	Sink	Sink
Output Voltage (V max.)			0.4	0.4	0.4	0.4
Current per Output (mA max.)			10.0	10.0	10	20
Magnetics Type			Unipolar	Bipolar*	Unipolar	Unipolar
Magnetic Gauss Char. & Temp.						
	−40 to 85°C	Max. Op.	450	130	190	400
		Min. Rel.	170	−130	60	200
		Min. Dif.	20	40	10	50
	25°C Typ.	Typ. Op.	400	90	150	350
		Typ. Rel.	185	−90	100	280
		Typ. Dif.	20	180	30	70

* Not necessarily latching

Analog position sensors

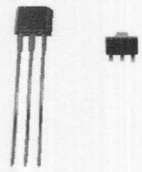
GENERAL INFORMATION

Analog devices are designed to produce an output voltage proportional to the intensity of the magnetic field to which it is exposed. Available package styles include: SS4, SS1, 9SS, SS89, SS9 and 103SR series.

- The 9SS and SS9 series have a Hall effect integrated circuit which is mounted on a ceramic substrate. Laser trimmed thick film resistors on the ceramic substrate result in consistent sensitivity from one device to the next, and provide compensation for temperature variations. The SS9 provides increased temperature stability and performance. These analog position sensors feature three pin in-line terminals on .100 inch mounting centers.
- SS49 and SS19 are supplied in very small, cost-effective plastic packages. They are available on tape-and-reel for automated assembly.
- The 103SR features a single adjustable linear output. An external bias resistor can be used to vary output voltage. The rugged aluminum housing has color coded leadwires.

For absolute maximum ratings, see page 42 and 43.

SS49/SS19 Analog position sensors



FEATURES

- *4 to 10 VDC supply voltage*
- *High output current capability – 10 mA continuous, 20 mA max.*
- *Ratiometric output*
- *Low supply current – 4 mA typ., for battery operation*
- *Very small, industry accepted packages*
- *Available on tape and reel for automated assembly*
- *Responds to North or South pole*
- *Linear output voltage over wide magnetic flux range*

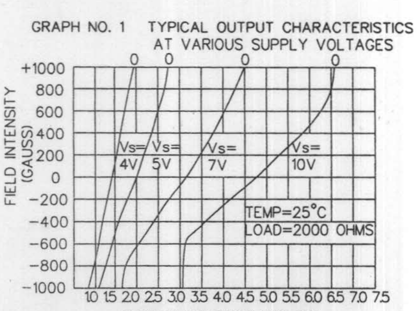
ORDER GUIDE

Catalog Listing	SS49/SS19
Supply Voltage	4 to 10 VDC
Supply Current	4 mA typ.
Output Type	Sourcing
Output Voltage @ 0 Gauss	1.75 to 2.25 V @ 5 V, 25°C
Sensitivity (measured between −400 and +400 gauss)	.0.60 to 1.25 mV/ gauss

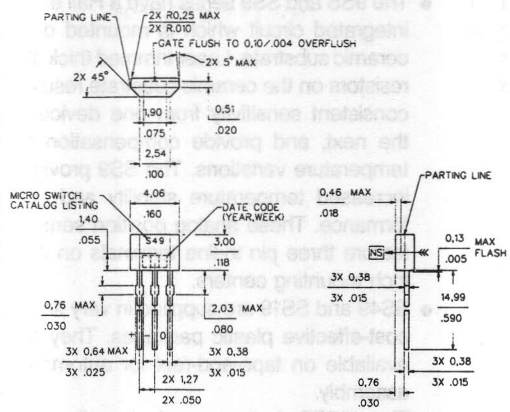
TYPICAL LINEAR OUTPUT CHARACTERISTICS*

Graph #1

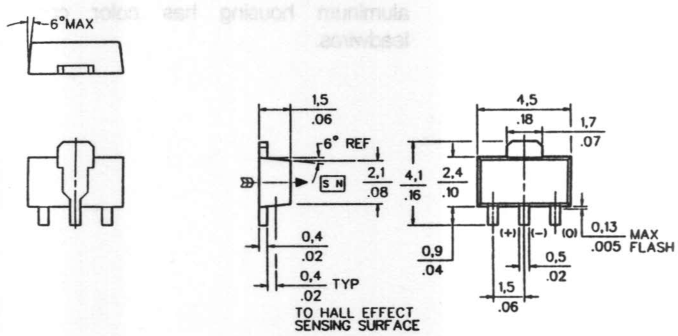
This graph displays the relationship between supply voltage and the combined effects of a change in sensitivity (gain) and null voltage output at room temperature. The sensitivity variation is represented by a change in the slope of the curve. The null voltage shifts the entire curve.



MOUNTING DIMENSIONS (For reference only)

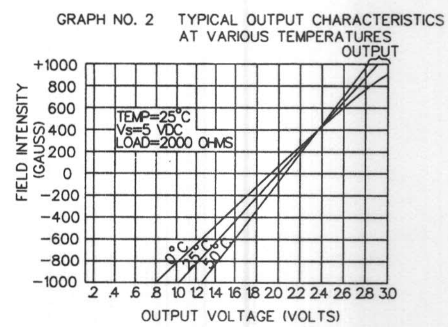


MOUNTING DIMENSIONS (For reference only)



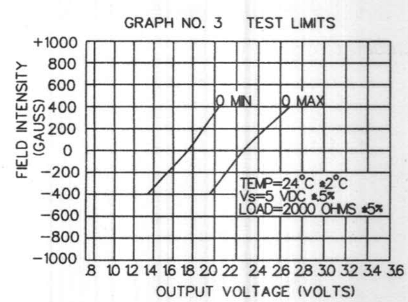
Graph #2

At 5 VDC supply voltage, these curves represent the typical performance of the SS49/SS19 over temperature.



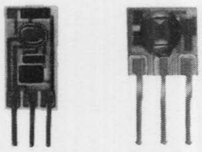
Graph #3

This graph indicates the conditions under which we test the SS49/SS19, and defines the limits of the product. These limits do not take temperature or supply voltage variations into account.



* Illustrated characteristics are typical. Production lot sensor characteristics will be in the general range of those shown.

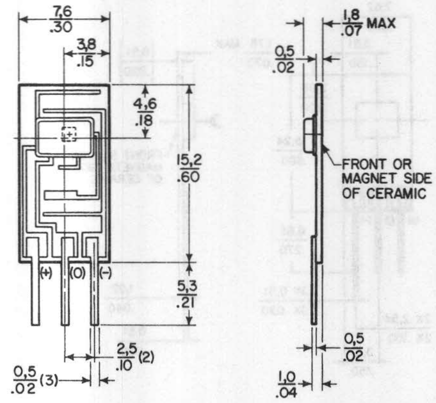
Analog position sensors 9SS/SS89



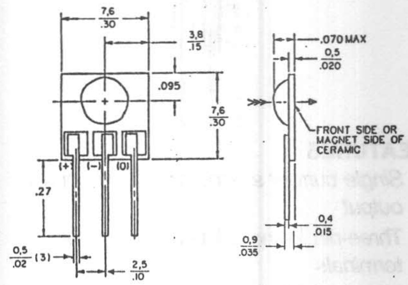
FEATURES

- *9SS – single current sourcing output*
- *SS89 – single current sinking or current sourcing output*
- *Three-pin in-line printed circuit board terminals*
- *Standard .100" mounting centers*
- *Laser trimmed thin film and thick film resistors minimize sensitivity variations and compensate for temperature variations*

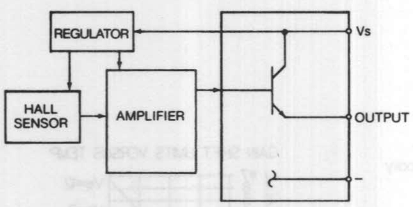
9SS MOUNTING DIMENSIONS
(for reference only)



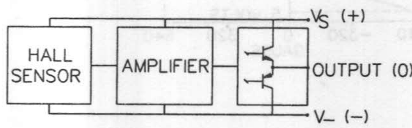
SS89 MOUNTING DIMENSIONS
(for reference only)



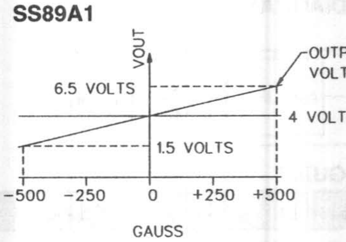
BLOCK DIAGRAM
91SS12-2



SS89A1



TRANSFER CHARACTERISTICS
SS89A1

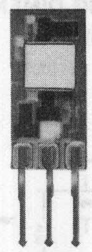


ORDER GUIDE

Catalog Listings		91SS12-2	SS89A1
Supply Voltage (VDC)		8 to 16 Performance @ 12 VDC	5.4 to 13.2 Performance @ 8 VDC
Supply Current (mA)		19 max.	13 typ., 18 max.
Output Current/Type		Ratiometric/Sourcing	Ratiometric/Sinking or Sourcing 1 mA max.
Response Time		3 μs max.	3 μs typ.
Magnetic Characteristics			
Span*		6.0 V (–400 to +400 gauss)	0.625 V_S (–500 to +500 gauss)
Null (Offset @ 0 gauss)		6.0 ± 0.6 V	4.0 ± 0.04 V
Sensitivity (mV per gauss @ 25°C)		7.5 ± 0.2	5.0 ± 0.1
Linearity (% span)		± 1.5	0.8 typ., –1.5 max.
Temperature Error (all %s reference 25°C value)			
Null Shift	–40 to +150°C	± 5%	
	–25 to +85°C	± 3%	± 0.03%/°C
	0 to +50°C	± 2%	
Gain Shift	–40 to 0°C	–0.034%/°C	
	–20 to +85°C		± 0.045%/°C
	0 to 150°C	–0.077%/°C	

* At 25°C

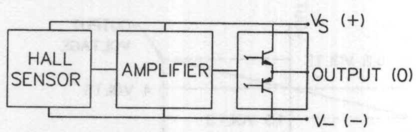
SS94B1 Analog position sensor



FEATURES

- *Single current sinking or current sourcing output*
- *Three-pin in-line printed circuit board terminals*
- *Standard .100" mounting centers*
- *Laser trimmed thin film and thick film resistors minimize sensitivity variations and compensate for temperature variations*

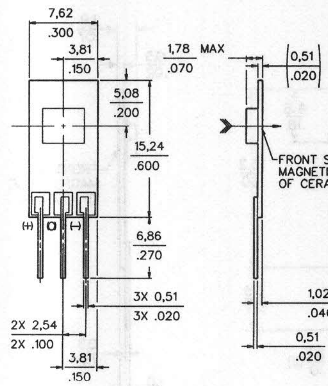
BLOCK DIAGRAM



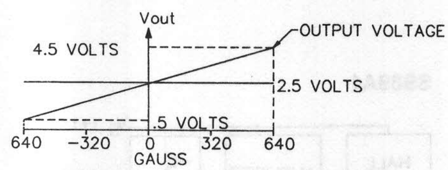
ORDER GUIDE

Catalog Listing	SS94B1
Supply Voltage (VDC)	4.5 to 12 Performance @ 5 VDC
Supply Current (mA)	8 typ., 11 max.
Output Current/Type	Ratiometric/Sinking or Sourcing 1 mA typ., 2 mA max.
Output Voltage Swing	
Negative gauss	0.4 V typ.
Positive gauss	V_S - 0.4 V typ.
Magnetic Characteristics @ 25°C, 5 VDC	
Span	4.0 V (−670 to +670 gauss, typ.)
Null (Offset @ 0 gauss)	2.5 ± 0.03 V
Sensitivity (mV per gauss)	3.125 ± 0.063
Linearity (% span)	−0.5 ± 0.5
Temperature Error (@ 25°C)	
Null Shift (%/°C)	± 0.03
Sensitivity (%/°C)	± 0.03

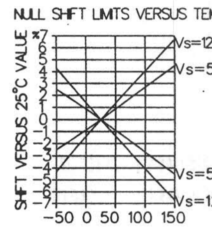
MOUNTING DIMENSIONS (for reference only)

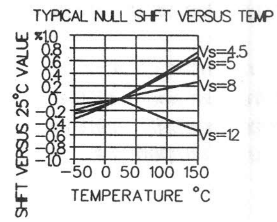


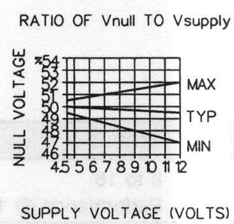
TRANSFER CHARACTERISTICS

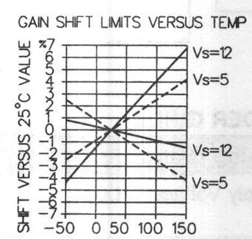


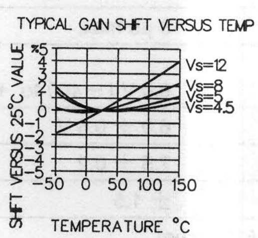
OUTPUT CHARACTERISTICS (for reference only)

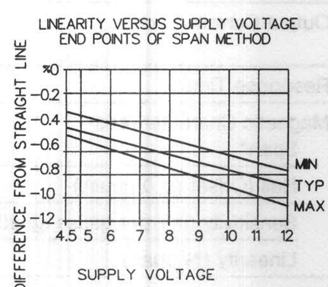


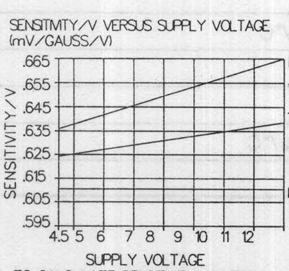




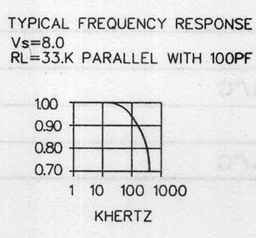




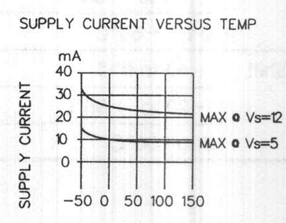




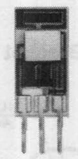
TO CALCULATE SENSITIVITY, MULTIPLY Y-AXIS VALUE TIMES SUPPLY VOLTAGE



Vout
Vout @ 1KHZ



TEMPERATURE °C



FEATURES

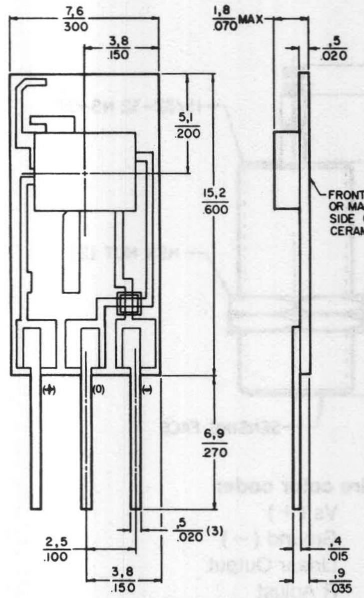
- *Single current sinking or current sourcing linear output*
- *Improved temperature stability*
- *Three pin in-line printed circuit board terminals*
- *Standard .100" mounting centers*
- *Laser trimmed thin film and thick film resistors minimize sensitivity variations and compensate for temperature variations*
- *Flux range of ±100 to ±2500 gauss*

OPERATION

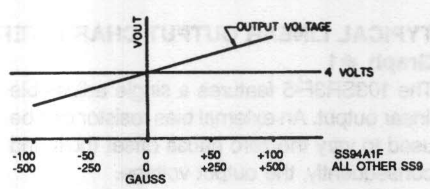
The SS9 utilizes a new Hall effect integrated circuit chip which provides increased temperature stability and performance with temperature drift approximately 10 times less than 9SS Series. Laser trimmed thick film resistors on the ceramic substrate and thin film resistors on the integrated circuit reduce null and gain shifts over temperature which results in consistent sensitivity from one device to the next.

MOUNTING DIMENSIONS (For reference only)

SS9



TRANSFER CHARACTERISTICS



SS9 ORDER GUIDE

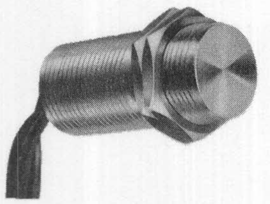
Catalog Listing	SS94A1	SS94A1B	SS94A1E	SS94A1F	SS94A1G	SS94A2	SS94A2C	SS94A2D
Main Feature	Gen. purpose	5 VDC operation	Low drift	High sensitivity	Gen. purpose	Noise shielded††	Noise shielded††	Noise shielded††
Supply Voltage (VDC)*	6.6 to 12.6	4.5 to 8.0	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6
Supply Current (mA)**	13 typ. 30 max.	8 typ. 17.5 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.
Output Current (mA) Sinking or Sourcing	1 max.	1 max.	1 max.	1 max.	1 max.	1 max.	1 max.	1 max.
Response Time (μ sec.)	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.
Magnetic Characteristics*** Span*	.625 V_S	.375 V_S	.625 V_S	.625 V_S	.625 V_S	.625 V_S	.625 V_S	.625 V_S
Range (gauss)*	−500 to +500	−500 to +500	−500 to +500	−100 to +100	−370 to +2000	−500 to +500	−1000 to +1000	−2500 to +2500
Sensitivity (mV/gauss @ 25°C)	5.0±.1	1.875±.100	5.0±.1	25.0±.5	2.0±.04	5.0±.1	2.50±.05	1.00±.02
Linearity† (% span)	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.	−0.8 typ. −1.5 max.
Vout (0 gauss @ 25°C)***	4.00±.04V	2.50±.05V	4.00±.04V	4.00±.08V	2.00±.04V	4.00±.04V	4.00±.04V	4.00±.04V
Temperature Error (all %s reference 25°C value)* Null (%/°C)	±.02	±.025	±.01	±.10	±.02	±.02	±.0125	±.007
Gain (%/°C)	±.02	±.025	±.02	+.02 −.04	±.02	±.02	±.02	±.02

* −40° to 125°C.
** Excludes load. Typical at 25°C/Maximum at −40°C.
*** @ V_s = 5 VDC for SS94A1B only/@ V_s = 8 VDC for all others.
† Derived from straight line between end points.
†† Silver coating on back of ceramic is electrically connected to − terminal.

Null voltage (Vout at 0 gauss) and sensitivity are ratiometric to supply voltage.

Application consideration: The output is clamped at the high end. Clamping voltage may be as low as 9VDC. The output will not exceed the clamping voltage regardless of field strength or supply voltage.

103SR Analog position sensors



FEATURES

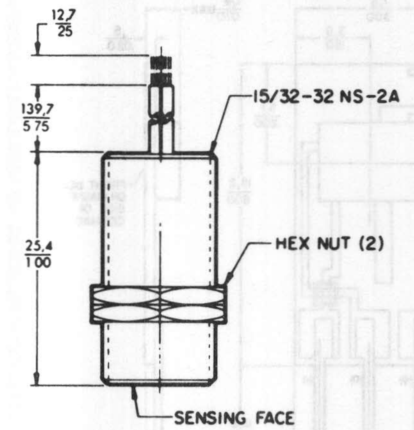
- *Rugged, sealed threaded aluminum housing NEMA 3, 3R, 3S, 4, 12 and 13 requirements*
- *22 gauge, 6 inch stranded leadwires, color coded and teflon insulated*
- *Adjustable mounting*

NOTE: For digital sensors, see page 16.

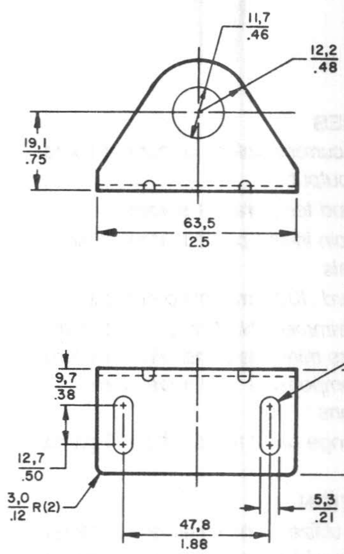
103SR ORDER GUIDE

Catalog Listing	103SR3F-5
Supply Voltage (VDC)	4 to 10
Supply Current (mA max.)	3.5
Output Voltage (V)	1.75 to 2.25V at 5V, 0 gauss
Sensitivity	(−400 to +400 gauss) 0.75 to 1.06mV/gauss

MOUNTING DIMENSIONS (For reference only)



1SR15 Mounting Bracket



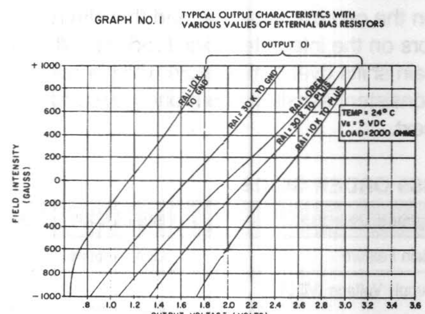
Leadwire color code:

Red	Vs (+)
Black	Ground (−)
Gray	Linear Output
White	R Adjust

TYPICAL LINEAR OUTPUT CHARACTERISTICS*

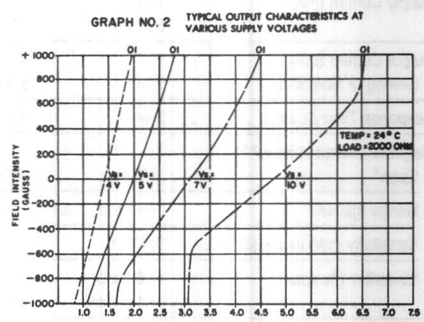
Graph #1

The 103SR3F-5 features a single adjustable linear output. An external bias resistor can be used to vary the zero gauss offset (null) and consequently, the output voltage.



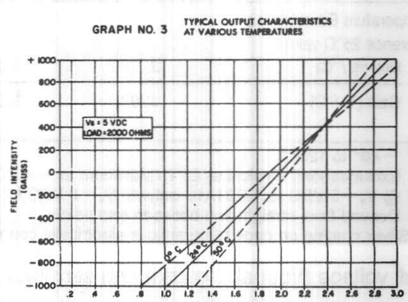
Graph #2

These curves represent the typical output characteristics at various supply voltages.



Graph #3

At 5 VDC supply voltage, these curves represent the typical performance of the 103SR3F-5 over temperature.



* Illustrated characteristics are typical. Production lot sensor characteristics will be in the general range of those shown.

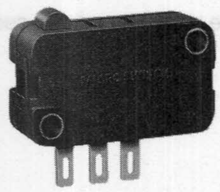
Integral magnet position sensors

GENERAL INFORMATION
MICRO SWITCH combines digital Hall effect sensors with integral magnets to produce the XL and VX series mechanically operated solid state sensors.

- The XL and VX series feature a permanent magnet mounted on the plastic plunger which operates a digital Hall effect sensor. When actuated, the sensor produces a sinking output. Mounting dimensions and mechanical characteristics are similar to MICRO SWITCH's popular V3 and V7 electromechanical snap-action switch series. The XL series offers three pin solder/quick-connect termination. The VX series features AMP or Molex plug-in connectors.

For absolute maximum ratings, see page 42 and 43.

XL Solid state basic switch



FEATURES

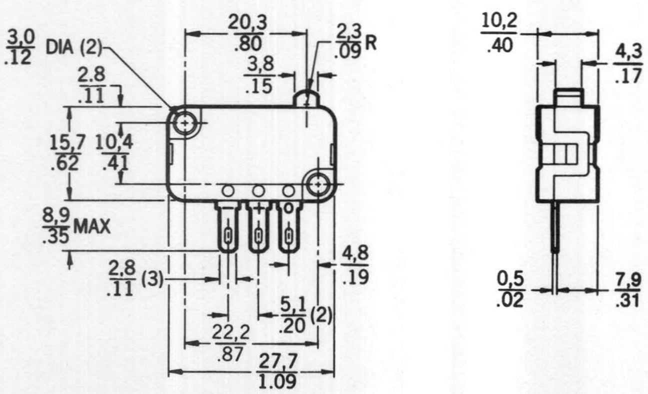
- *Plunger operated*
- *Three pin solder/quick-connect terminals*
- *Terminal housing available that uses Molex .110" push-on terminals*
- *Digital current sinking output*
- *Normally high or normally low*
- *Low operating forces — as little as .15 oz. with lever*
- *Variety of actuator versions — uses all standard MICRO SWITCH V3 levers**
- *Same mounting centers as V3 snap-action switch*

* See Catalog 10, Basic Switches

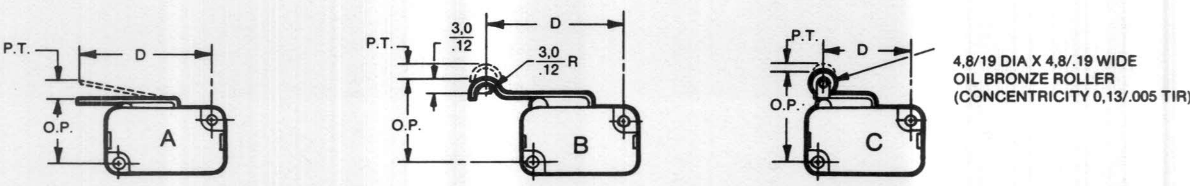
ELECTRICAL SPECIFICATIONS

Series	37XL	47XL
Supply Voltage (VDC)	4.5 to 5.5	6 to 24
Supply Current (mA max.)	4.0	13.0
Output Type	Sink	Sink
Current per Output (mA)	8	20

MOUNTING DIMENSIONS (For reference only)



OPERATING CHARACTERISTICS DIMENSIONS



Characteristics: P.T. — Pretravel; O.T. — Overtravel; D.T. — Differential Travel; O.P. — Operating Position

XL ORDER GUIDE

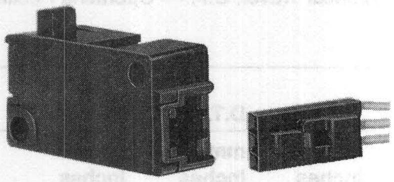
Catalog Listings 5VDC Type Sinking	6-24VDC Type Sinking	Operating Force Ounces Newtons	Lever Actuation Point (D)	Lever Style*	P.T. max. mm inches	O.T. min. mm inches	D.T. max. mm inches	O.P. mm inches
37XL31-01	47XL31-01	.35 ±.15 0,10 ± ,04						
37XL31-02	47XL31-02	1.25 ± .15 0,35 ± ,04	— —	— (Pin Plunger)	1,52 .060	0,86 .034	0,18 .007	14,48 ± 0,25 .570 ± .010
37XL31-03	47XL31-03	3.00 ± .70 0,83 ± 0,19						
37XL31XA-11	47XL31XA-11	.40 ± .20 0,11 ± ,06						
37XL31XA-12	47XL31XA-12	1.40 ± .35 0,39 ± ,09	21,84 .860	A (Short)	1,91 .075	0,89 .035	0,25 .010	15,49 ± 0,38 .610 ± .015
37XL31XA-13	47XL31XA-13	3.2 ± .70 0,89 ± ,19						
37XL31XA-21	47XL31XA-21	.20 (+.15, −.07)** 0,06 (+,04, −,02)						
37XL31XA-22	47XL31XA-22	.70 ± .25 0,19 ± ,07	35,56 1.400	A (Medium)	3,81 .150	1,90 .075	0,38 .015	15,62 ± 0,76 .615 ± .030
37XL31XA-23	47XL31XA-23	1.4 ± .35 0,39 ± ,09						
37XL31XA-31	47XL31XA-31	.10 ± .07** 0,03 ± ,02						
37XL31XA-32	47XL31XA-32	.35 ± .20 0,10 ± ,06	59,44 2.340	A (Long)	7,11 .280	3,56 .140	0,76 .030	15,67 ± 1,40 .617 ± .055
37XL31XA-33	47XL31XA-33	.70 ± .35 0,19 ± ,09						
37XL31XB-11	47XL31XB-11	.20 (+.15, −.07)** 0,06 (+,04, −,02)						
37XL31XB-12	47XL31XB-12	.70 ± .25 0,19 ± ,07	32,64 1.285	B (Siml. Roller)	3,94 .155	1,65 .065	0,38 .015	18,72 ± 0,89 .737 ± .035
37XL31XB-13	47XL31XB-13	1.4 ± .35 0,39 ± ,09						
37XL31XC-01	47XL31XC-01	.40 ± .20 0,11 ± ,06						
37XL31XC-02	47XL31XC-02	1.4 ± .35 0,39 ± ,09	20,57 .810	C (Short Roller)	1,90 .075	0,86 .034	0,25 .010	20,83 ± 0,38 .820 ± .015
37XL31XC-03	47XL31XC-03	3.2 ± .70 0,89 ± ,19						

* Other lever styles are available. Contact MICRO SWITCH sales office.
** Lever may not be self-returning.

NOTE: The output transistors of the listings shown are "normally off." They are not conducting when the plunger is in free position. To order devices which are "normally on" (conducting when plunger is in free position), substitute 32 for the 31 immediately following the XL in the catalog listing.

Example: 37XL**32**XA-12

VX Solid state basic switch



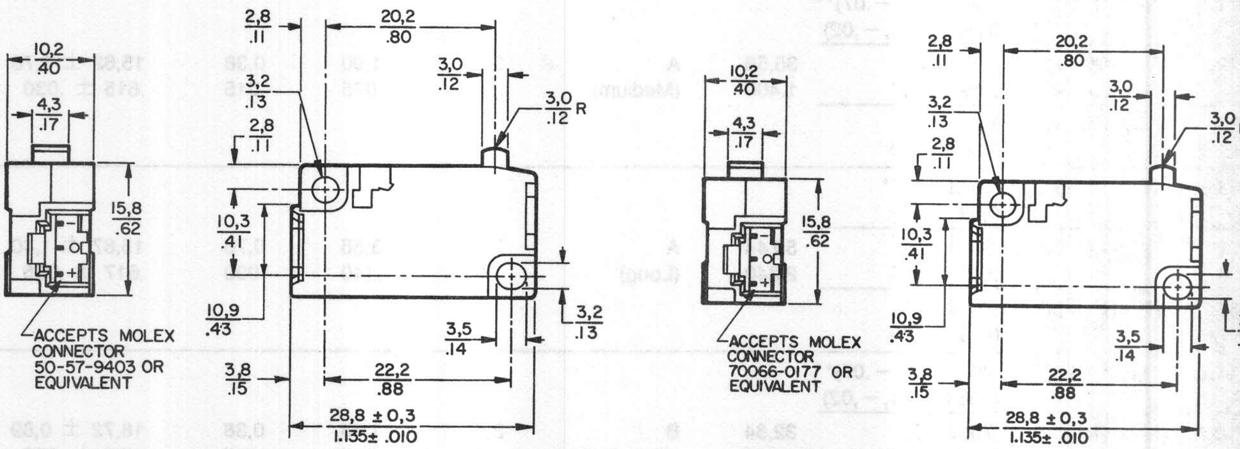
FEATURES

- *Plunger operated digital output*
- *Low force operation*
- *− 40° to + 70°C operating temperature*
- *Direct interface to solid state circuits*
- *Reverse voltage protection*
- *Rugged construction*
- *Tested to over 100 million operations*
- *Wide variety of standard levers and actuators available*
- *Lever external to switch body*
- *Industry standard mounting holes*
- *No external terminals — uses standard keyed and locking plug-in connectors*
- *UL recognized, CSA certified*

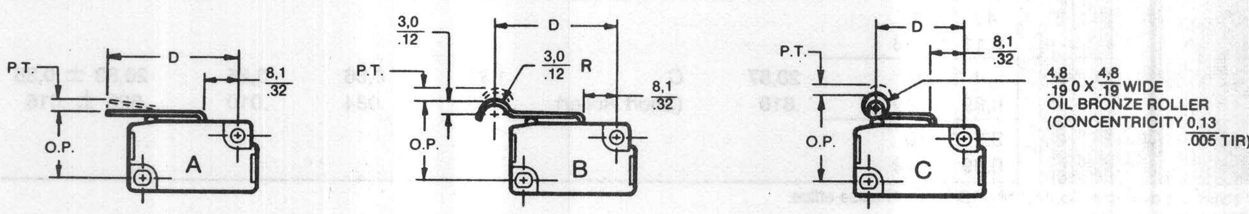
ELECTRICAL SPECIFICATIONS

Supply Voltage (VDC)	4.5 to 24
Supply Current (mA max.)	15
Output Type	Sink
Current per Output (mA)	10

MOUNTING DIMENSIONS For reference only)



OPERATING CHARACTERISTICS DIMENSIONS



Characteristics: P.T. — Pretravel; O.T. — Overtravel; D.T. — Differential Travel; O.P. — Operating Position

VX ORDER GUIDE

Catalog Listings: Accepts AMP Conn.	Catalog Listings: Accepts Molex Conn.	Operating Force: Ounces / Newtons	Lever Actuation Point (D)	Lever Style*	P.T. max mm / inches	O.T. min. mm / inches	D.T. max. mm / inches	O.P. mm / inches
VX10	VX12	.35 + .18 (−.14) 0,1 (+,05, −,04)	—	— (Pin Plunger)	2,16 .085	1,02 .040	0,30 .012	14,73 ±0,51 .580 ± .020
VX80	VX82	3.0 ± .88 0,83 ± ,24						
VX10-A1	VX12-A1	.35 ± .2 0,1 ± ,06	21,8 .860	A (Short)	2,59 .102	1,02 .040	0,36 .014	15,37 ± 0,69 .605 ± .027
VX80-A1	VX82-A1	2.8± 1.1 ,78 ± ,31						
VX10-A2	VX12-A2	0.2 ± .1 ,06 ± ,03	35,6 1.400	A (Medium)	5,33 .210	2,16 .085	0,71 .028	15,34 ± 1,40 .604 ± .055
VX80-A2	VX82-A2	1.41 ± .50 ,39 ± ,14						
VX10-A3	VX12-A3	.10 ± .07 ,03 ± ,02	59,4 2.340	A (Long)	9,96 .392	4,06 .160	1,32 .052	15,24 ± 2,64 .600 ± .104
VX80-A3	VX82-A3	.75 + .35 (−.25) ,21 (+0,1 −,07)						
VX10-B1	VX12-B1	0.20 + .15 (−.10) ,06 (+,04 −,03)	32,6 1.285	B (Simulated Roller)	5,21 .205	1,91 .075	0,64 .025	18,52 ± 1,47 .729 ± .058
VX80-B1	VX82-B1	1.55 ± .53 ,43 ± ,15						
VX10-C1	VX12-C1	.40 ± .20 ,11 ± ,06	20,6 .810	C (Short Roller)	2,49 .098	1,02 .040	0,33 .013	20,68 ± 0,69 .814 ± .027
VX80-C1	VX82-C1	3.0 ± 1.06 ,83 ± ,29						

* Other lever styles are available. Contact MICRO SWITCH sales office.

Termination

Terminal pins accept two different types of connectors (not furnished) depending on the switch housing:

1. AMP 102241-1
   MICRO SWITCH part number:
   VX1A — connector & receptacle unassembled.
   VX1A-01 — connector & receptacle pre-assembled with 5.4″, 24 gauge lead wires.
2. Molex 50-57-9403
   MICRO SWITCH part number:
   VX2A — connector & receptacle unassembled.
   VX2A-01 — connector & receptacle pre-assembled with 5.4″, 24 gauge lead wires.

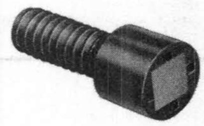
NOTE: The output transistors of the listings shown are "normally off." They are not conducting and the output voltage is High with plunger in free position. To order devices which are "normally on" and the output voltage is Low (conducting with plunger in free position), change the second digit from 0 to a 1, or a 2 to a 3 in the catalog listing.

Examples: VX**10**-A1 — VX**11**-A1
VX**12**-A1 — VX**13**-A1

MG Magnets

GENERAL INFORMATION

Several bar and ring magnets for actuating Hall effect sensors are available from MICRO SWITCH. Bar magnets, in various sizes and strengths, are ideal for sensors with unipolar magnetic characteristics. The ring magnets, with alternate South and North poles on the outside diameter, are especially useful for sensors with bipolar magnetic characteristics. (For more information on magnets and methods of magnet actuation, see Application Data.)

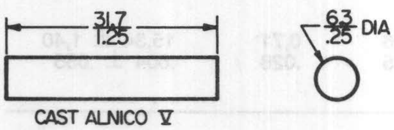


FEATURES

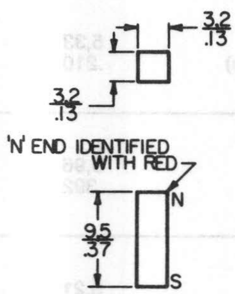
- *Wide variety of sizes and shapes*
- *Wide variety of magnetic materials*
- *Threaded bushings available on some listings for easy installation*

MOUNTING DIMENSIONS (for reference only)

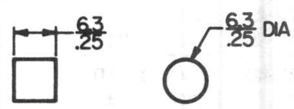
101MG3



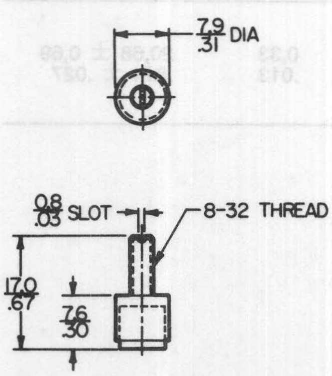
101MG2L1



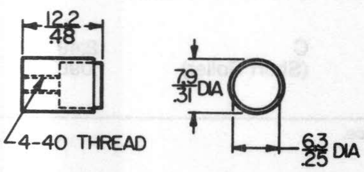
101MG7



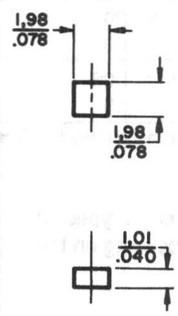
102MG11



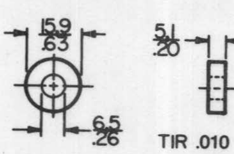
102MG15



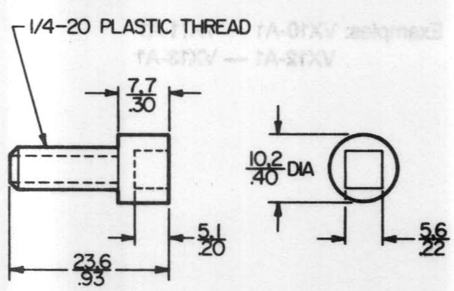
103MG5



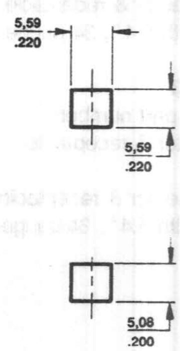
105MG5R2



106MG10



103MG8



MG ORDER GUIDE — BAR MAGNETS

Catalog Listings	101MG3	101MG7*	101MG2L1*	102MG11*	102MG15*	103MG5**	103MG8**	106MG10**
Outside Diameter	6,3 0.25	6,3 0.25	3,2 0.125	7,9 0.31	7,9 0.31	2,0 .078	5,6 .220	10,2 0.40
Length	31,7 1.25	6,3 0.25	9,5 0.375	17,0 0.67	12,2 .48	2,0 .078	5,6 .220	23,6 0.93

* Bulk packaging in 100 unit lots. Add **-BP** to catalog listing.
** 125 pieces per tube. Poles not marked.

MG ORDER GUIDE — RING MAGNETS

Catalog Listings	105MG5R2	105MG5R4
Outside Diameter	15,9 0.625	15,9 0.625
# Pole Pairs	2	4

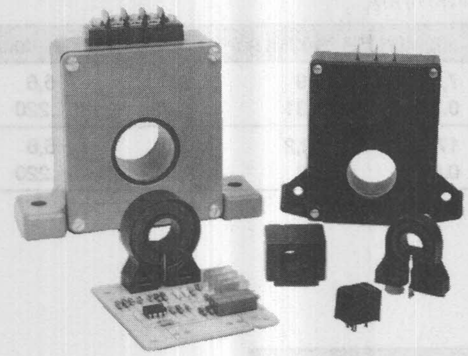
MAGNET SELECTION GUIDE

This guide is designed to aid in determining the best magnet for use with a Hall effect sensor. There are several factors to consider when choosing a magnet. The most important is gap distances. There must be adequate magnetic gauss to operate the sensor at the correct distance. By using the maximum operate magnetic gauss characteristics (see sensor order guides), you can determine which magnet(s) will operate the sensor. Other important factors include temperature range and the physical environment of the application.

Material and Process	Physical Strength	Temperature Range*	Magnetic Shock Resistance	Resistance To Demagnetization	Gap Distance** & Gauss Level @ 25°C 0,25 .010	0,76 .030	1,27 .050	2,54 .100	3,81 .150	5,08 .200	Catalog Listing
Alnico V Cast	Good	− 40 to 300°C	Poor	Fair	1460	1320	1170	810	575	420	**101MG3**
Alnico VIII Sintered	Good	− 40 to 250°C − 40 to 140°C − 40 to 140°C	Good	Excellent	1050	900	755	470	295	195	**101MG7** **102MG11** **102MG15**
Alnico VI Sintered	Good	− 40 to 250°C	Good	Good	730	550	410	205	115	75	**101MG2L1**
Indox 1 Pressed	Good	0 to 100°C	Good	Excellent	700	520	375	175	85	45	**105MG5R2** **105MG5R4**
Rare Earth Pressed	Poor	− 40 to 250°C	Good	Excellent	1110 2620 2620	630 2100 2100	365 1600 1600	120 940 940	55 550 550	25 350 350	**103MG5** **103MG8** **106MG10**

* Magnet will not be damaged over temperature range.
** Gap distance from Hall element.

CS Current sensors



OPERATION

MICRO SWITCH CS series solid state current sensors monitor either alternating (AC) or direct (DC) current. This series includes a wide assortment of devices ranging from digital output current detectors capable of sensing a few hundred milliamps to linear sensors capable of monitoring several thousand amps. The entire family of CS current sensors provides a means of accurate low-cost current sensing.

If one of the following listings is close, but does not quite meet the application requirements, please contact your local MICRO SWITCH Sales Office. Our building block approach allows easy customization to meet most requirements.

Current sensors monitor current flow. Digital sensors produce a digital output signal. Linear sensors produce an analog output signal. When these signals have reached a predetermined level, the control system logic is instructed to perform a function. The digital signal with its logic level output may sound an alarm, start a motor, open a valve, or shut down a pump. The linear signal duplicates the waveform of the current being sensed and is ideal for use as a feedback element to control a motor or regulate the amount of work being done by a machine.

Some CS current sensors utilize a through-hole design. This feature insures that there will not be any DC insertion loss in the conductor. In addition, the through-hole design simplifies installation by eliminating the need for direct connection, which minimizes energy dissipation, and provides output isolation at no extra cost. MICRO SWITCH CS through-hole current sensors cannot be damaged by overcurrent.

Current sensing is accomplished by measuring the magnetic field surrounding a current-carrying conductor. The conductor is passed through the flux collector which concentrates the magnetic field at the sensing element. The magnetic field is directly proportional to the current passing through the conductor. Thus, there is a direct relationship between the output voltage of the current sensor and the level of input current. The waveform of this output voltage will track the waveform of the measured current. The through-hole design electrically isolates the sensor and insures that it will not be damaged by overcurrent or high voltage transients.

Linear Current Sensors

MICRO SWITCH CS series linear current sensors incorporate our 91SS12-2 and SS94A1 linear output Hall effect transducer (LOHET™). The sensing element is centered in the gap of the flux collector and is assembled in a printed circuit board mountable housing. This housing is available in four configurations (as shown in mounting dimension Figures 1, 1a, 2, and 2a on page 35). Normal mounting is with 0.375 inch long 4-40 screw and square nut (not provided) inserted in the housing. The combination of the sensor, flux collector, and housing comprises the holder assembly.

When sensing zero current the output voltage of the current sensor is approximately equal to one half of the supply voltage (Voffset = 0.5 Vcc). CS series linear current sensors will sense current in both directions. Current flow in one direction will cause the output voltage to increase from its offset value. Current flow in the opposite direction will cause the output voltage to decrease from its offset value. The output voltage range is from 25% of the supply voltage to 75% of the supply voltage (0.25 Vcc $<$ Vo $<$ 0.75 Vcc).

While sensing either AC or DC current, the linear output voltage will track the waveform of the sensed current.

The output of these devices can be adjusted by varying the supply voltage, varying the gap cut in the flux collector, or increasing the number of turns of the conductor passing through the center of the flux collector. Devices on page 35 are ratiometric.

FEATURES

- *Digital or linear output*
- *AC or DC current sensing*
- *Through-hole design*
- *Fast response time*
- *Output voltage isolation from input*
- *Minimum energy dissipation*
- *Maximum current limited only by conductor size*
- *Adjustable performance and built-in temperature compensation assures reliable operation*
- *Accurate, low cost sensing*
- *Operating temperature range −25 to 85°C*

Adjustable Linear Current Sensors

MICRO SWITCH offers two families of linear current sensors with adjustable offset voltage and sensitivity. Both families utilize the previously described linear current sensors mounted to a small printed circuit board containing additional circuitry. The adjustable feature enables the user to define the exact range of operation. The offset voltage and sensitivity are controlled by two trimpots soldered to the printed circuit board. These sensors are ratiometric.

Digital Current Sensors

Each MICRO SWITCH CS series digital current sensor provides a logic level output that changes from approximately Vcc to 0.4 volts when the sensed current exceeds the operate point (the exception being the CSDB1CC which changes from 0.4 volts to Vcc when the operate point is exceeded). Each digital sensor will operate on AC or DC current, but the output will turn off at every zero crossing when sensing AC current.

Note: Operate and release currents are specified in Amps-Peak. When monitoring AC current using a digital sensor, peak values should be used. Multiply the RMS values by 1.414 to obtain the peak value.

Industrial Output Current Sensors

Current sensors with industrial outputs easily interface with programmable controllers and other industrial control and monitoring devices. They have 4 to 20 mA or 1 to 5 VDC outputs and are packaged in a low-cost open PC board configuration or enclosed housings. These devices include a regulator. Therefore, they are not ratiometric.

APPLICATION

- *Variable speed motor controls*
- *Automotive diagnostics (battery drain detector)*
- *Ground fault detectors*
- *Motor overload protection*
- *Current monitoring of electric welders*
- *Ring transfer relay in telephone systems*
- *Energy management systems*
- *Protection of power semiconductors*
- *Control system diagnostics*

HOW TO INTERPRET CURRENT SENSOR SPECIFICATIONS

The following definitions will help the user understand the characteristics of the MICRO SWITCH current sensor line.

Adjustable Operating Range — The adjustable linear current sensors give the user the option of changing the sensitivity according to the maximum sensed current of the application. The on-board sensitivity adjustment allows the user to alter the amplification of the Hall effect sensor, thereby adjusting the amount of sensed current needed to achieve maximum output voltage.

Example	Vcc = 12V
Voffset	= Vcc/2 = 6V
Vo maximum	= (75%)Vcc = 9V
Vspan available	= 3V

Assume a current maximum of 45 amps is determined. The user would then apply 45 amps through the toroid and adjust the sensitivity where indicated until a 9 volt output is achieved. The sensitivity is then determined as (3V)/(45A) = 67mV/A. This design allows for maximum sensor flexibility.

For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when the sensor is adjusted toward its minimum operate range. Any circuit noise is also amplified.

Offset Shift — The offset shift refers to the effect of temperature on the offset voltage. It is defined as a percentage of reading per degree Celsius. Example: Offset voltage is 6.0V at 25°C. The offset shift is ±0.05%/°C. Therefore, the offset voltage at 35°C is 6.0V ± (0.05%/°C) (6.0V) (10°C) = 6.0V ± 0.03V. The offset shift due to temperature increases as the device is operated toward the temperature extremes.

Offset Voltage — The offset voltage is the voltage received from the current sensing element when no current is flowing through the flux collector. This is also known as the null voltage.

Operate Current — The operate current is the level of current required to cause a change in logic state from the state at no current flow. For example, the logic output is high at no current flow. When the current level is increased to the operate point, the logic output goes low.

Ratiometric — Characteristics vary in proportion to supply voltage.

Release Current — The release current is the level of current required to cause a change in logic state as the current flow decreases from the operate point.

NOTE: The CSDB1CC listing has positive logic output, current off, logic low, current on, and logic high. The other digital current detectors have inverse logic output.

Response Time (linear) — Measured from the time the input current reaches 90% of its full scale value to the time when the sensor output reaches 90% of final value. This assumes rise time of 1 microsecond or less on input.

Response Time (digital) — The length of time it takes the output to switch to within ten percent of the supply voltage from the negative supply after the rated operate point is reached on the input. Measured time will vary proportionally with the overdrive current.

Sensed Current (Amps Peak) — The SS94A1 and 91SS12-2 linear output Hall effect sensors have a maximum sensed range. The toroid (flux collector) in each holder assembly has a gap in which the sensor is placed. By varying the width of the gap (lg), the level of current that produces the amount of gauss necessary to saturate the sensor is varied. In otherwords, the maximum/minimum output of the Hall element will always be obtained at rated gauss excitation. The current level needed to achieve that maximum/minimum output depends on the width of the gap in the flux collector.

Temperature Range — The −25° to +85°C specified is the operating temperature range that the current sensor has been rated. The performance specifications are not considered to be valid outside the specified temperature range.

CS Current sensors

LINEAR CURRENT SENSORS ORDER GUIDE — BOTTOM MOUNT WITH 9SS SENSOR, SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts ± 10%)	Sensitivity mV/NI At 12 VDC Nominal	± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA1CD	1	8 to 16	19	57	Vcc/2	49.6	5.8	±.05	3
CSLA1CE	1	8 to 16	19	75	Vcc/2	39.4	4.4	±.05	3
CSLA1DE	2	8 to 16	19	75	Vcc/2	39.1	4.8	±.05	3
CSLA1CF	1	8 to 16	19	100	Vcc/2	29.7	2.7	±.05	3
CSLA1DG	2	8 to 16	19	120	Vcc/2	24.6	2.1	±.05	3
CSLA1CH	1	8 to 16	19	150	Vcc/2	19.6	1.8	±.05	3
CSLA1DJ	2	8 to 16	19	225	Vcc/2	13.2	1.2	±.05	3
CSLA1EJ	1a	8 to 16	19	225	Vcc/2	13.2	1.5	±.05	3
CSLA1DK	2	8 to 16	19	325	Vcc/2	9.1	1.7	±.05	3
CSLA1EK	1a	8 to 16	19	325	Vcc/2	9.4	1.3	±.05	3
CSLA1EL	1a	8 to 16	19	625	Vcc/2	5.6	1.3	±.05	3

BOTTOM MOUNT WITH SS9 SENSOR, SINK/SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts ± 2%)	Sensitivity mV/NI At 8 VDC Nominal	± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA2CD	1	6 to 12	20	72	Vcc/2	32.7	3.0	±.02	3
CSLA2CE	1	6 to 12	20	92	Vcc/2	26.1	2.1	±.02	3
CSLA2DE	2	6 to 12	20	92	Vcc/2	25.6	2.2	±.02	3
CSLA2CF	1	6 to 12	20	125	Vcc/2	19.6	1.3	±.02	3
CSLA2DG	2	6 to 12	20	150	Vcc/2	16.2	1.1	±.02	3
CSLA2DJ	**2**	**6 to 12**	**20**	**225**	**Vcc/2**	**8.7**	**0.6**	**±.020**	**3**
CSLA2DH	2	6 to 12	20	235	Vcc/2	9.8	1.1	±.0125	3
CSLA2EJ	1a	6 to 12	20	310	Vcc/2	7.6	0.7	±.0125	3
CSLA2DK	2	6 to 12	20	400	Vcc/2	5.8	0.5	±.0125	3
CSLA2EL	1a	6 to 12	20	550	Vcc/2	4.3	0.4	±.0125	3
CSLA2EM	1a	6 to 12	20	765	Vcc/2	3.1	0.3	±.007	3
CSLA2EN	1a	6 to 12	20	950	Vcc/2	2.3	0.2	±.007	3

SIDE MOUNT WITH 9SS SENSOR, SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts ± 10%)	Sensitivity mV/NI At 12 VDC Nominal	± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA1GD	2a	8 to 16	19	57	Vcc/2	49.6	5.8	±.05	3
CSLA1GE	2a	8 to 16	19	75	Vcc/2	39.4	4.4	±.05	3
CSLA1GF	2a	8 to 16	19	100	Vcc/2	29.7	2.7	±.05	3

SIDE MOUNT WITH SS9 SENSOR, SINK/SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts ± 2%)	Sensitivity mV/NI At 8 VDC Nominal	± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA2GD	2a	6 to 12	20	72	Vcc/2	32.7	3.0	±.02	8
CSLA2GE	2a	6 to 12	20	92	Vcc/2	26.1	2.1	±.02	8
CSLA2GF	2a	6 to 12	20	125	Vcc/2	19.6	1.3	±.02	8
CSLA2GG	2a	6 to 12	20	150	Vcc/2	12.7	0.6	±.02	8

NOTE: When monitoring purely AC current with zero DC component, a capacitor can be inserted in series with the output of the current sensor. The capacitor will block out the effect of the temperature variation of the offset voltage which increases the accuracy of the device.

MOUNTING DIMENSIONS (for reference only)

Figure 1

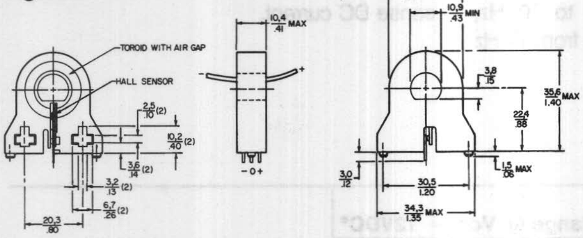


Figure 1a

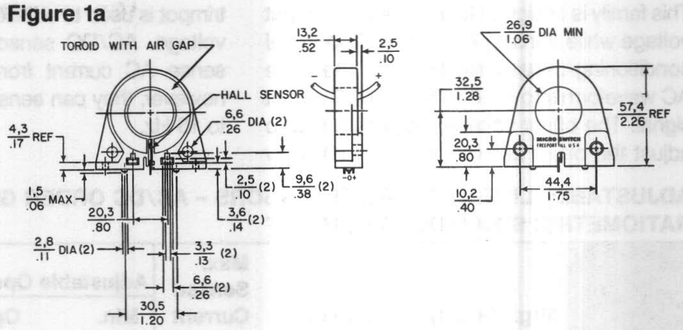


Figure 2

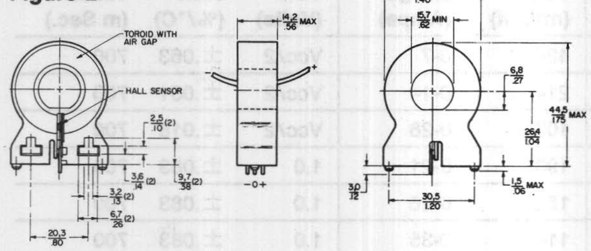
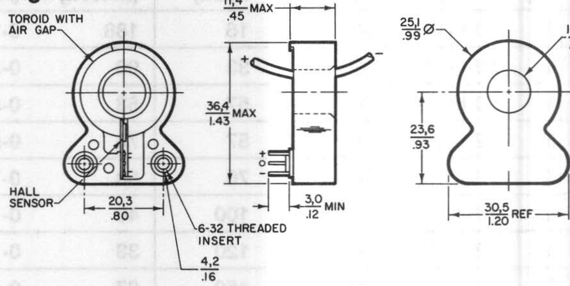


Figure 2a



ADJUSTABLE LINEAR SENSORS DC/DC

This family is designed to provide a DC output voltage while sensing DC current. By adjusting the offset voltage trimpot the user can adjust the offset to one half of the supply voltage. The full scale current output voltage can be adjusted by the use of the sensitivity trimpot. Depending on the direction of current flow, the output voltage wil either increase or decrease from the offset value. These sensors can sense current from 0 to 50 kHz.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

Due to magnetic properties a residual magnetic field can remain present in the flux collector at zero current. To facilitate resolution of DC current in the lower 1% of the dynamic range, adjust the null offset after a nominal level of current has passed thru the sensor.

ADJUSTABLE LINEAR CURRENT SENSORS – DC/DC ORDER GUIDE RATIOMETRIC SINK/SOURCE OUTPUT

Catalog Listings	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Max. Sensed Current (Amps-Peak)	Adjustable Operating Range @ Vcc = 12VDC* Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Volt. (Volts)	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLB1AD	3	10 to 15	30	57	53	0-57	90	0-33	Vcc/2	±.03	8
CSLB1BE	4	10 to 15	30	75	40	0-75	75	0-40	Vcc/2	±.03	8
CSLB1AF	3	10 to 15	30	100	30	0-100	55	0-55	Vcc/2	±.03	8
CSLB1BG	4	10 to 15	30	120	25	0-120	46	0-65	Vcc/2	±.03	8
CSLB1AH	3	10 to 15	30	150	20	0-150	38	0-80	Vcc/2	±.03	8
CSLB1BJ	4	10 to 15	30	225	13	0-225	26	0-115	Vcc/2	±.03	8
CSLB1BK	4	10 to 15	30	325	9	0-325	16	0-185	Vcc/2	±.03	8

* For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when adjusting toward a minimum operate range; noise is also amplified.

MOUNTING DIMENSIONS (for reference only)

Figure 3

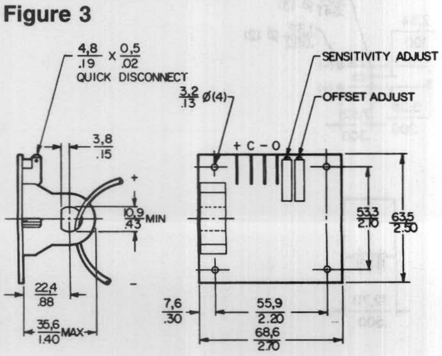
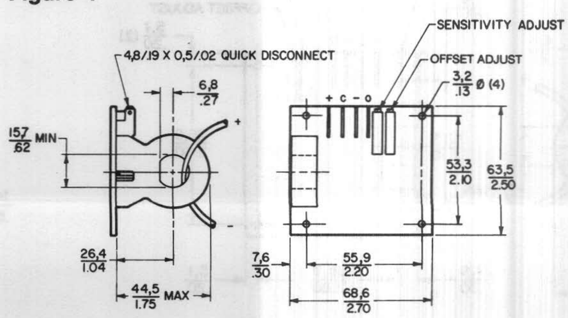


Figure 4



CS Current sensors

AC/DC

This family is designed to provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC output signal. The offset voltage trimpot is used to adjust the offset at 1.0 volts. The sensitivity trimpot is used to adjust the maximum output voltage. AC/DC sensors are optimized to sense AC current from 50 Hz to 70 Hz, however, they can sense current from 10 Hz to 15 Hz.

NOTE: The input of the AC/DC sensors is capacitive coupled and should not be used to sense DC current.

ADJUSTABLE LINEAR CURRENT SENSORS - AC/DC ORDER GUIDE
RATIOMETRIC SINK/SOURCE OUTPUT

Catalog Listings	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Max. Sensed Current (Amps-Peak)	Adjustable Operating Range @ Vcc = 12VDC* Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Volt. (Volts)	Offset Shift (%/°C)	Response Time (m Sec.)
CSLB2AB	5	10 to 15	30	16	188	0-16	428	0-7	Vcc/2	±.063	700
CSLB2AC	5	10 to 15	30	33	90	0-33	214	0-14	Vcc/2	±.031	700
CSLB2AD	5	10 to 15	30	57	53	0-57	107	0-28	Vcc/2	±.018	700
CSLC2AD	5	12	30	57	70	0-57	190	0-21	1.0	±.083	700
CSLC2BE	6	12	30	75	53	0-75	154	0-26	1.0	±.083	700
CSLC2AF	5	12	30	100	40	0-100	114	0-35	1.0	±.083	700
CSLC2BG	6	12	30	120	33	0-120	98	0-41	1.0	±.083	700
CSLC2AH	5	12	30	150	27	0-150	80	0-50	1.0	±.083	700
CSLC2BJ	6	12	30	225	18	0-225	53	0-75	1.0	±.083	700
CSLC2BK	6	12	30	325	12	0-325	34	0-118	1.0	±.083	700

* For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when adjusting toward a minimum operate range; noise is also amplified.

The common terminal "C" is used when the sensor is excited by dual supplies. With dual excitation, the offset voltage is 0 volts for the first three AC/DC listings shown above. For the remaining AC/DC sensors, the offset voltage is adjusted to −5.0 volts when using ±6 volt supplies.

MOUNTING DIMENSIONS (for reference only)

Figure 5

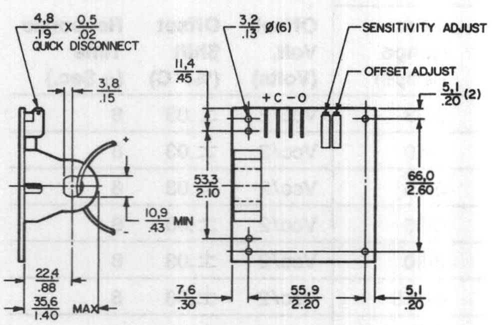


Figure 6

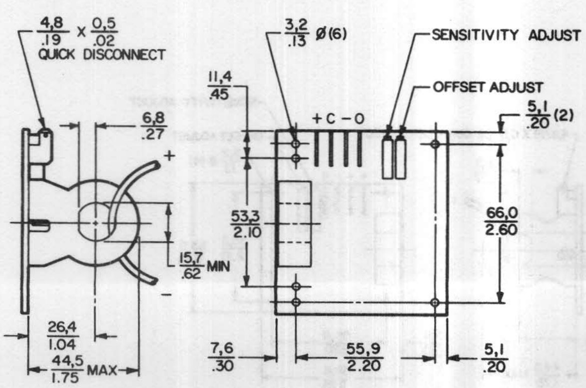
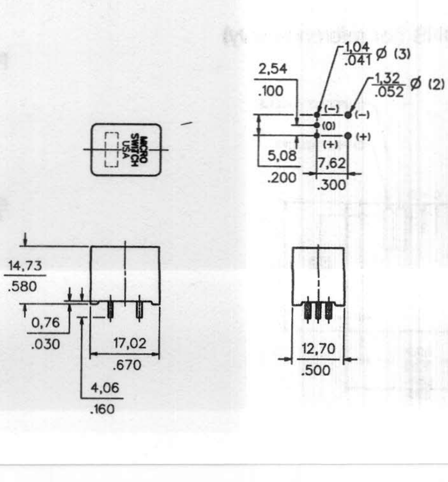


Figure 11



CS DIGITAL SENSORS

Series-connect current sensors produce a digital logic level output. When the current being sensed reaches a predetermined level, the output changes state. Thru hole digital sensors are below.

SERIES-CONNECT DIGITAL CURRENT SENSORS ORDER GUIDE, SINKING OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Operate Current @25°C (Amps)	Release Current @25°C (Amps)	Max. Continuous Current (Amps)	Resistance (m Ohm)	Inductance (μH)	Supply Volt. (Volts DC)	Output Volt. (Volts)	Output Current (mA) Sinking	Response Time (μ Sec.)
CSDD1EJ	11	1.3	.9	5	17	7	4.5 to 24	0.4	20mA	60
CSDD1ED	11	3.5	2.6	10	8	7	4.5 to 24	0.4	40mA	60
CSDD1EC	11	5.0	3.8	20	5	4	4.5 to 24	0.4	40mA	60
CSDD1EE	11	6.5	4.9	20	4	4	4.5 to 24	0.4	40mA	60
CSDD1EF	11	9.0	6.8	20	3	3	4.5 to 24	0.4	40mA	60
CSDD1EG	11	10.0	7.6	20	3	3	4.5 to 24	0.4	40mA	60
CSDD1EH	11	15.0	11.4	20	2	3	4.5 to 24	0.4	40mA	60

DIGITAL CURRENT DETECTORS ORDER GUIDE, SINKING OUTPUT

Catalog Listings	Mtg. Dim. Fig.	Pinout Style	Operate Current @ 25°C (Amp-Turns) Min.	Nom.	Max.	Operate Current −25°C to +85°C (Amp-Turns)	Release Current −25°C to +85°C (Amp-Turns Min.)	Supply Volt. (Volts DC)	Output Volt. (Volts)	Output Current (mA) Sinking	Response Time (μ Sec.)
CSDA1BA	9	2	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	6 to 16	0.4	20mA	100
CSDA1BC	9	2	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	6 to 16	0.4	20mA	100
CSDB1CC	10	—	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	8 to 16	0.4	100mA	100
CSDC1BA	9	2	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	5 ± 0.2	0.4	20mA	100
CSDC1BC	9	2	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	5 ± 0.2	0.4	20mA	100
CSDA1AA	9	1	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	6 to 16	0.4	20mA	100
CSDA1AC	9	1	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	6 to 16	0.4	20mA	100
CSDC1AA	9	1	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	5 ± 0.2	0.4	20mA	100
CSDC1AC	9	1	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	5 ± 0.2	0.4	20mA	100
CSDC1DA	9	3	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	5 ± 0.2	0.4	20mA	100
CSDA1DA	9	3	0.32	0.50	0.88	0.50 + 0.5/−0.25	0.08	6 to 16	0.4	20mA	100
CSDC1DC	9	3	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	5 ± 0.2	0.4	20mA	100
CSDA1DC	9	3	2.2	3.5	6.5	3.5 + 4.0/−1.8	0.60	6 to 16	0.4	20mA	100

* The CSDB1CC has positive logic output, current off, logic low, current on, logic high.

NOTE: The sensor shown in Figure 9 can be ordered with either a 0.5 amp or 3.5 amp operate point. The sensor shown in Figure 10 has a 3.5 amp operate point.

MOUNTING DIMENSIONS (for reference only)

Figure 9

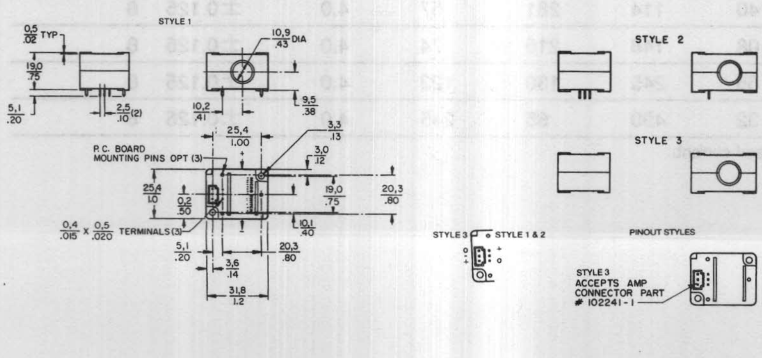
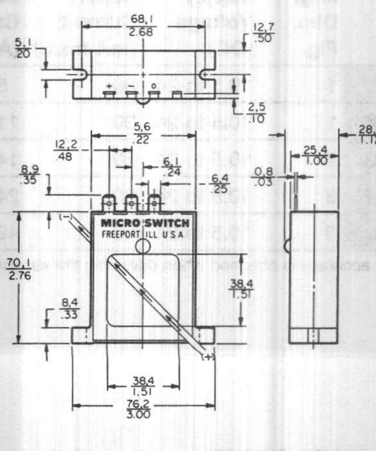


Figure 10



CS Current sensors

ADJUSTABLE LINEAR SENSORS WITH STANDARD INDUSTRIAL OUTPUTS

The through-hole sensor housing is mounted on a small printed circuit board containing additional circuitry and two trimpots. Offset voltage is controlled by one trimpot, while the other controls sensitivity. By adjusting the trimpots, the user defines the exact range of operation. A regulator is used on each circuit. Output is not ratiometric. Terminate 1 to 5 volt outputs with $\geq$500 ohms. Terminate 4 to 20 mA with $\leq$250 ohms.

DC/DC sensors provide a DC output voltage/current while sensing DC current. The offset voltage trimpot enables the offset to be either 1 volt or 4 milliamps. The full scale output voltage/current can be adjusted by using the sensitivity trimpot.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

AC/DC sensors provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC or a 4 to 20 mA output signal. The offset trimpot adjusts the offset at a 1.0 volt or 4 mA. The sensitivity trimpot adjusts the maximum output voltage/current. AC/DC sensors can sense AC current from 50 to 400 Hz.

NOTE: The input of AC/DC sensors is capacitive coupled. They should not be used to sense DC current.

OPERATING CHARACTERISTICS

ADJUSTABLE LINEAR DC/DC SENSORS WITH 1.0 to 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (μ Sec. typ.)
CSLE4AD	1	10.5 to 24	30	57	70	57	138	29	1.0	±0.092	8
CSLF4AF	1	10.5 to 24	30	114	35	114	70	57	1.0	±0.092	8
CSLE4BG	2	10.5 to 24	30	148	27	148	54	74	1.0	±0.092	8
CSLE4FH	3	10.5 to 24	30	245	16	245	33	123	1.0	±0.092	8
CSLE4FL	3	10.5 to 24	30	490	8	490	16	245	1.0	±0.063	8

Note: Output current 10mA max. source, 1mA max. sink.

AC/DC SENSORS WITH 1.0 to 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE5AC	1	10.5 to 24	30	24	167	24	500	8	1.0	±0.04	150
CSLE5AD	1	10.5 to 24	30	72	56	72	167	24	1.0	±0.04	150
CSLE5BE	2	10.5 to 24	30	92	43	92	129	31	1.0	±0.04	150
CSLE5FG	3	10.5 to 24	30	153	26	153	78	51	1.0	±0.04	150
CSLE5FK	3	10.5 to 24	30	408	10	408	29	136	1.0	±0.04	150
CSLE5FN	3	10.5 to 24	30	950	4	950	12	340	1.0	±0.04	150

Note: Output current 10mA max. source, 1mA max. sink.

DC/DC SENSORS WITH 4.0 to 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (μA/NI)	Oper. Range (Amps)	Max. Sens. (μA/NI)	Oper. Range (Amps)	Offset Current (mA)	Offset Shift (%/°C)	Response Time (μSec typ.)
CSLF4AD	1	10.5 to 24	30	57	28	57	552	29	4.0	±0.125	8
CSLF4AF	1	10.5 to 24	30	114	140	114	281	57	4.0	±0.125	8
CSLF4BG	2	10.5 to 24	30	148	108	148	216	74	4.0	±0.125	8
CSLF4FH	3	10.5 to 24	30	245	65	245	130	123	4.0	±0.125	8
CSLF4FL	3	10.5 to 24	30	490	32	490	65	245	4.0	±0.125	8

* Optimum accuracy is obtained when operating the sensor at maximum sensed current.

ADJUSTABLE LINEAR AC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range Min. Sens. (µA/NI)	Oper. Range (Amps)	Max. Sens. (µA/NI)	Oper. Range (Amps)	Offset Current (mA)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLF5AC	1	10.5 to 24	30	24	667	24	2000	8	4.0	±0.043	150
CSLF5AD	1	10.5 to 24	30	72	222	72	667	24	4.0	±0.043	150
CSLF5BE	2	10.5 to 24	30	92	174	92	516	31	4.0	±0.043	150
CSLF5FG	3	10.5 to 24	30	153	105	153	314	51	4.0	±0.043	150
CSLF5FK	3	10.5 to 24	30	408	39	408	118	136	4.0	±0.043	150
CSLF5FN	3	10.5 to 24	30	950	17	950	47	340	4.0	±0.043	150

* Optimum accuracy is obtained when operating the sensor at maximum sensed current.

MOUNTING DIMENSIONS

Dimensions shown are for reference only.

Key: 0,0 = mm / 0.00 = in.

Fig. 1

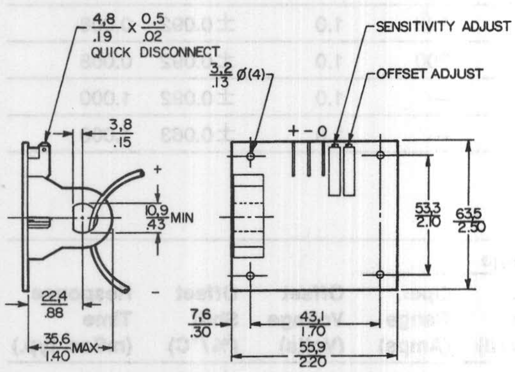


Fig. 2

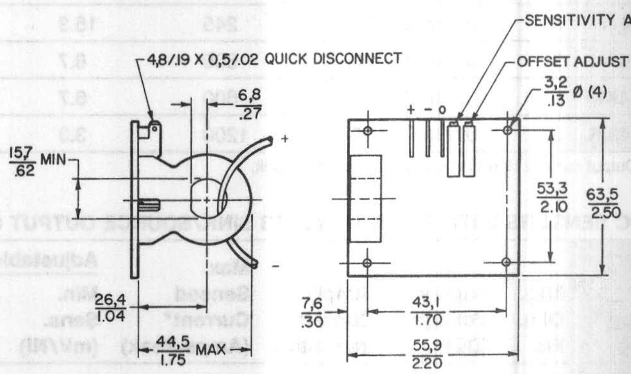
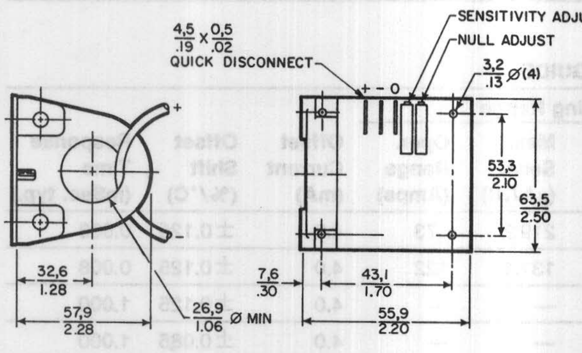


Fig. 3



CS Current sensors

INDUSTRIAL ENCLOSED LINEAR CURRENT SENSORS

DC/DC sensors provide a DC output voltage/current while sensing DC current. The offset voltage trimpot enables the offset to be either 1 volt or 4 milliamps. The full scale output voltage/current can be adjusted by using the sensitivity trimpot.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

AC/DC sensors provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC or a 4 to 20 mA output signal. The offset trimpot adjusts the offset at 1.0 volt or 4 mA. The sensitivity trimpot adjusts the maximum output voltage/current. These sensors can sense AC current from 50 to 1000 Hz. (AC/DC sensors without the adjustable performance feature are factory adjusted @ 60 Hz.)

NOTE: The input of AC/DC sensors is capacitive coupled. They **cannot** be used to sense DC current.

Sensors with adjustable performance feature. Several of these industrial linear current sensors have a pair of trimpots which enable the user to define the exact range of operation (see figures 1 and 2). Offset voltage is controlled by one trimpot, while the other controls sensitivity. By adjusting these trimpots, the user defines the exact range of operation and maximizes sensor sensitivity. A regulator is used on each circuit. The output is not ratiometric. Terminate 1 to 5 volt outputs with $\geq$500 ohms. Terminate 4 to 20 mA outputs with $\leq$250 ohms.

OPERATING CHARACTERISTICS

ENCLOSED LINEAR DC/DC SENSORS WITH 1.0 TO 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE4HG	4	10.5 to 24	30	147	27.2	147	54.8	73	1.0	±0.092	0.008
CSLE4JH	5	10.5 to 24	30	245	16.3	245	32.8	122	1.0	±0.092	0.008
CSLE4JM	5	10.5 to 24	30	600	6.7	600	13.3	300	1.0	±0.092	0.008
CSLE4KM	6	10.5 to 24	30	600	6.7	600	—	—	1.0	±0.092	1.000
CSLE4KP	6	10.5 to 24	30	1200	3.3	1200	—	—	1.0	±0.063	1.000

Note: Output current 10mA max. source, 1mA max. sink.

AC/DC SENSORS WITH 1.0 TO 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE5HE	4	10.5 to 24	30	92	43.5	92	1333	30	1.0	±0.04	150
CSLE5JG	5	10.5 to 24	30	153	26.1	153	78.4	51	1.0	±0.04	150
CSLE5JK	5	10.5 to 24	30	408	9.8	408	294	136	1.0	±0.04	150
CSLE5KQ	6	10.5 to 24	30	1500	2.7	1500	—	—	1.0	±0.04	150

Note: Output current 10mA max. source, 1mA max. sink.

DC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (µA/NI)	Oper. Range (Amps)	Max. Sens. (µA/NI)	Oper. Range (Amps)	Offset Current (mA)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLF4HG	4	10.5 to 24	30	147	108.8	147	219.2	73	4.0	±0.125	0.008
CSLF4JH	5	10.5 to 24	30	245	65.3	245	131.1	122	4.0	±0.125	0.008
CSLF4KM	6	10.5 to 24	30	600	26.7	600	—	—	4.0	±0.125	1.000
CSLF4KP	6	10.5 to 24	30	1200	13.3	1200	—	—	4.0	±0.085	1.000

*Optimum accuracy is obtained when operating the sensor at maximum sensed current.

ENCLOSED LINEAR AC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

					Adjustable Operating Range						
Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Min. Sens. (μA/NI)	Oper. Range (Amps)	Max. Sens. (μA/NI)	Oper. Range (Amps)	Offset Current (mA)	Offset Shift (%/°C)	Response Time (mSec typ.)
CSLF5HD	4	10.5 to 24	30	18	869.6	18	2666.7	6	4.0	±0.043	150
CSLF5HE	4	10.5 to 24	30	92	173.9	92	533.33	30	4.0	±0.043	150
CSLF5JG	5	10.5 to 24	30	153	104.57	153	313.73	51	4.0	±0.043	150
CSLF5JK	5	10.5 to 24	30	408	39.2	408	117.6	136	4.0	±0.043	150
CSLF5KQ	6	10.5 to 24	30	1500	10.7	1500	–	–	4.0	±0.043	150

*Optimum accuracy is obtained when operating the sensor at maximum sensed current.

MOUNTING DIMENSIONS

Dimensions shown are for reference only.

Key: $\frac{0,0 = \text{mm}}{0.00 = \text{inches}}$

Fig. 4

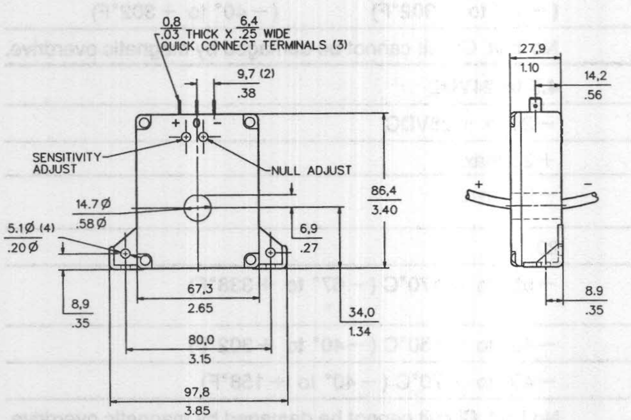


Fig. 5

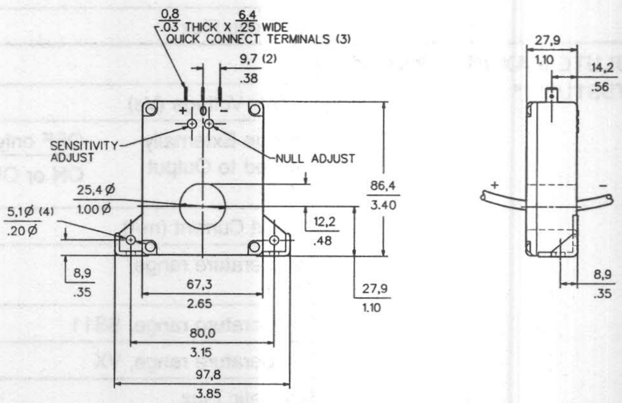
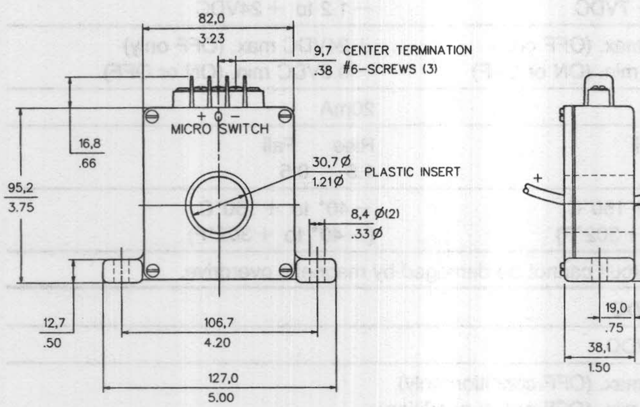


Fig. 6



Absolute maximum ratings

ABSOLUTE MAXIMUM RATINGS — 103SR/400SR/XL*

		4.5 to 5.5VDC	6 to 24VDC
Supply Voltage (Vs)		− 1.2 to + 10VDC	− 1.2 to + 24VDC
Voltage Externally Applied to Output (VDC)	Sink/OFF only	+ 10 max.	+ 24 max.
	Sink/ON or OFF	− 0.5 min.	− 0.5 min.
	Source	+ 6.5 max. (ON or OFF)	+ 6.5 max. (OFF only)
	Source/ON only	− 0.5 min.	(Vs + 4)
Output Current (mA)	Sink/Single	20	40
	Sink/Dual	10/output	20/output
	Source/Single	40	20
	Source/dual	20/output	20/output
Switching Time (μsec. max.)	Sink/Rise	2.0	1.5
	Sink/Fall	1.0	0.5
	Source/Rise	1.0	0.5
	Source/Fall	1.0	2.0
Temperature		− 40° to + 150°C (− 40° to + 302°F)	+ 40° to + 150°C (− 40° to + 302°F)
Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.	

ABSOLUTE MAXIMUM RATINGS — SS41/SS11/VX*

		4.5 to 24VDC
Supply Voltage (Vs)		− 24 to + 28VDC
Voltage Externally Applied to Output (VDC)	OFF only	+ 28 max.
	ON or OFF	− 0.5 min.
Output Current (mA)		20
Temperature range, SS41		− 55° to + 170°C (− 67° to + 338°F)
Temperature range, SS11		− 40° to + 150°C (− 40° to + 302°F)
Temperature range, VX		− 40° to + 70°C (− 40° to + 158°F)
Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.

ABSOLUTE MAXIMUM RATINGS — SS2*/2SSP

	4.5 to 5.5VDC	6 to 24VDC
Supply Voltage (Vs)	− 1.2 to + 7VDC	− 1.2 to + 24VDC
Voltage Externally Applied to Output	+ 20VDC max. (OFF only) − 0.5VDC min. (ON or OFF)	+ 24VDC max. (OFF only) − 0.5VDC min. (ON or OFF)
Output Current	20mA	20mA
Switching Time (μsec. max.)	Rise 1.5, Fall 0.5	Rise 1.5, Fall 0.5
Temperature	− 40° to + 150°C (− 40° to + 302°F)	− 40° to + 150°C (− 40° to + 302°F)
Magnetic Flux	No limit. Circuit cannot be damaged by magnetic overdrive.	

ABSOLUTE MAXIMUM RATINGS — SS400*

	3.8 to 24VDC
Supply Voltage	1 to + 25VDC
Voltage Externally Applied to Output	+ 25VDC max. (OFF condition only) − 0.5VDC min. (OFF or ON condition)
Output ON Current	50mA maximum
Temperature range Operating Storage	 − 55 to + 160°C (− 67 to + 320°F) − 65 to + 160°C (− 85 to + 320°F)
Magnetic Flux	No limit. Circuit cannot be damaged by magnetic overdrive.

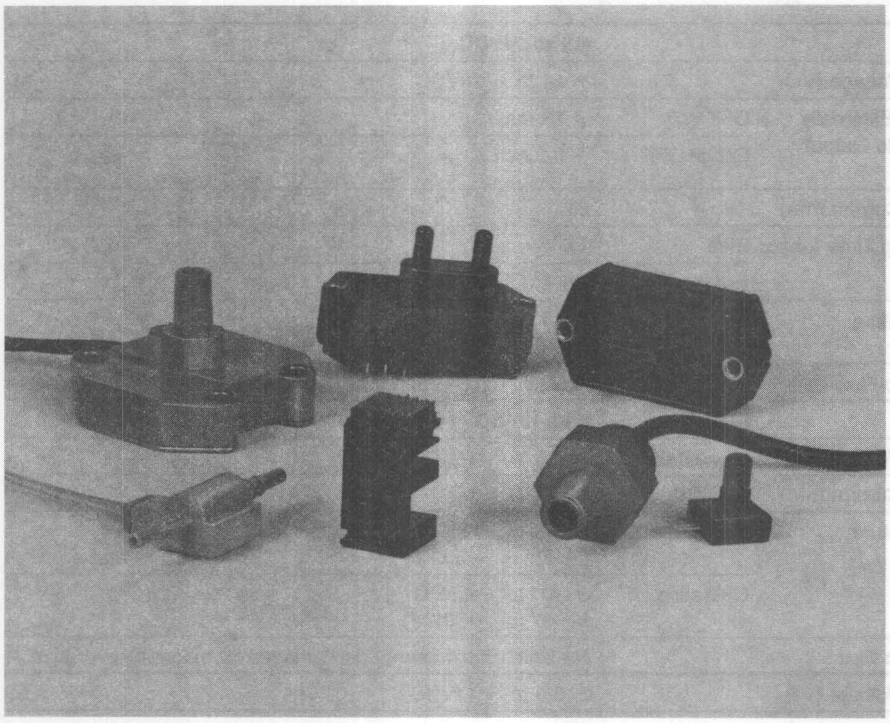
* As with all solid state components, sensor performance can be expected to deteriorate as rating limits are approached, however, sensors will not be damaged unless the limits are exceeded.

Absolute maximum ratings

ABSOLUTE MAXIMUM RATINGS — SR3*			**4.5 to 24VDC**
	Supply Voltage (Vs)		−24 to +28VDC
	Voltage Externally Applied to Output (VDC)	OFF only	+28 max.
		ON or OFF	−0.5 min.
	Output Current (mA)		20
	Switching Time (μsec. max.)	Rise	1.5
		Fall	0.5
	Temperature	Storage/ Operating	−40° to +125°C (−40° to +257°F)
	Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.
ABSOLUTE MAXIMUM RATINGS — 9SS*			**8 to 16VDC**
	Supply Voltage (Vs)		−0.5 to +18VDC
	Output Current (mA)		10
	Temperature	Storage	−40° to +150°C (−40° to +302°F)
		Operating	−40° to +150°C (−40° to +302°F)
	Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.
ABSOLUTE MAXIMUM RATINGS — SS9*	Supply Voltage (Vs)		−0.5 to +14VDC
	Output Current (mA)		10
	Temperature	Storage	−55° to +150°C (−67° to +302°F)
		Operating	−40° to +150°C (−40° to +302°F)
	Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.

* As with all solid state components, sensor performance can be expected to deteriorate as rating limits are approached; however, sensors will not be damaged unless the limits are exceeded.

Additional solid state sensors



PRESSURE SENSORS

MICRO SWITCH pressure sensors are small, low cost and reliable. You can handle a wide range of applications with your choice of the following features and performance characteristics.

- *Solid state, piezoresistive integrated circuit sensing*
- *Pressure ranges from ±2.5″ H_2O to 250 psi*
- *Absolute, differential or gage measurement*
- *Amplified output*
- *Signal conditioning*
- *Temperature compensation*
- *Supply voltages from 8 to 16 VDC*
- *Null and full scale output trim*
- *PC board, leadwire and cable termination*
- *Plastic, die-cast aluminum and stainless steel housings*
- *And some meet MIL standards for shock, vibration, and moisture resistance*

10PC Series — Miniature gage and differential sensors.

20PC Series — Miniature sensors with a unique conductive seal. Versatile, easily modified package.

120PC Series — Combines low cost, differential measurement and low level output.

130PC Series — Measures just over 16mm square and weighs only 5 grams.

140PC Series — Offers amplified output with temperature compensation over a wide range. Includes a current output version that avoids voltage drop problems.

150PC Series — Unique flow-thru design for convenient application.

160PC Series — High sensitivity and low pressure measurement from 0-1 psi.

170PC Series — Low level output with high sensitivity from 0-1 psi pressure measurement.

180PC Series — Miniature amplified sensors.

190PC Series — Precision ultra-low pressure differential sensors. Bidirectional ±2.5″ H_2O and 0 to 5″ H_2O pressure measurement.

230PC Series — Rugged, corrosion-resistant plastic or stainless steel housing.

240PC Series— Epoxy coated die-cast aluminum housing and O-ring seals for environmental protection.

For further information, request Catalog 15 (84-07908) and pressure sensor product literature.

Advanced sensing capabilities

At MICRO SWITCH, sensor development is an outgrowth of a continuing process of evaluating and responding to customer requirements. Demands of increased productivity, improved quality and reduced manufacturing costs are the same demands placed on sensors as the equipment and systems in which they play a critical role. Today, MICRO SWITCH is dedicating significant engineering resources to the development of sensors beyond those cataloged here. These include:

- **AIR FLOW SENSING**
  Sensors that measure mass air flow in 0 to 200 sccm range or differential air pressure in the 0-2″ H_2O range are available. A unique design, referred to as a microbridge, combines advanced thin film and chemical etching techniques. A heater resistor is used in conjunction with temperature sensors to create this dual function sensor. Request Catalog 15 (84-07908) and AWM Series literature.

- **COLOR SENSING**
  The ability to automatically detect the subtle differences in shades of color will have a significant impact on many industries. Color discrimination is a critical process control function in the manufacturing of paints, dyes, cosmetics, and textiles. And, in virtually every industry, it is an important aspect of quality control.

- **FIBER OPTIC SENSING**
  Managing a light signal in much the same fashion as an electrical signal, fiber optics allows sensing in areas that have created a challenge for electrical/electronic sensors. These include operations where high levels of RFI, EMI or hazardous dusts and gases are present.

- **LIQUID LEVEL SENSING**
  Advanced optics provide a highly reliable approach to determining liquid level. Extreme accuracy and packaging that withstands high temperatures and corrosive liquids, expands the application versatility of this sensing approach.

- **VISION SENSING**
  The "eyes" of the automated factory will see and remember the shape, position and orientation of the objects they are programmed to recognize or evaluate. Operating at assembly line speeds, these sensors will have a dramatic effect on productivity and inspection costs.

The above areas are representative of MICRO SWITCH's solid state sensing capabilities. If you have requirements associated with these or any other sensing area, ask your MICRO SWITCH representative or contact a nearby sales office listed on the back cover.

Current sink and current source interfacing

Application Notes

Linear and digital Hall effect are offered in two basic types — sinking or sourcing. A current sinking device (open collector, normally high) "sinks current from a load". Consequently, current flows from the load into the transducer **Figure 1.** A current sourcing device (open emitter, normally low) "sources current into a load" causing current to flow from the transducer into the load **Figure 2.**

The digital Hall effect sensor can be envisioned as a mechanical switch which allows current to flow when turned on and blocks current flow when turned off. The transducer will only switch low level DC voltages (24 VDC maximum) at currents of 40mA or less. The linear Hall effect transducer puts out a continuous signal proportional to the sensed magnetic field.

Conditions that must be met when interfacing with digital Hall effect sensors are: (1) the interface must appear as a load that is compatible with the output, and (2) the interface must provide the combination of current and voltage required in the application.

In applying Hall effect sensors, a pull-up resistor must be used in conjunction with a current sinking device and a pull-down resistor for current sourcing devices. The outputs are floating, therefore the pull-up or pull-down resistor helps establish a solid quiescent voltage level. These resistors also minimize the effect of small leakage currents from the output of the device or from the electronics with which the transducer is interfaced. Additionally, they provide better noise immunity and faster rise and fall times.

A pull-up resistor is connected directly across the positive terminal (+ supply) and output (0). When the device is deactuated, the input to the load is "pulled-up" to near V_{Supply}. In other words, a current sinking device will output a voltage equal to the supply voltage when it is in a non-operated state. In addition, it will output approximately 0.4 volts in an operated state (output transistor's saturation voltage plus a diode drop).

A pull-down resistor is connected directly across the output of the device and the negative terminal (ground). When the transducer is actuated, the input to the load rises to near V_{Supply} independent of the pull-down resistor. Conversely, when the device is deactuated, the input to the load is "pulled-down" to near ground potential. When selecting a pull-up or pull-down resistor, it must be determined if the interface will tolerate a resistance in parallel. If there is a parallel resistance, the total resistance and load current should be calculated to make sure the Hall effect transducer's output current will not be exceeded.

Current sink and current source interfacing

Figure 1
Current Sinking Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.

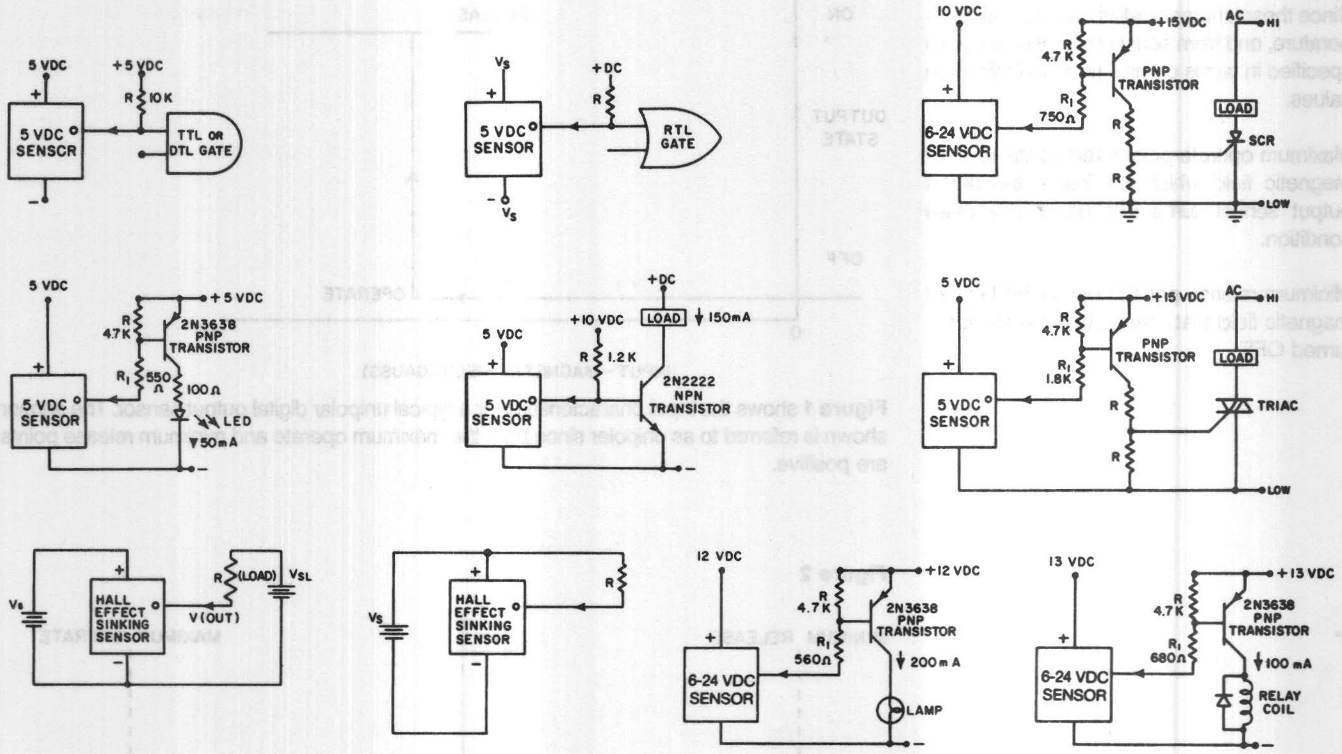
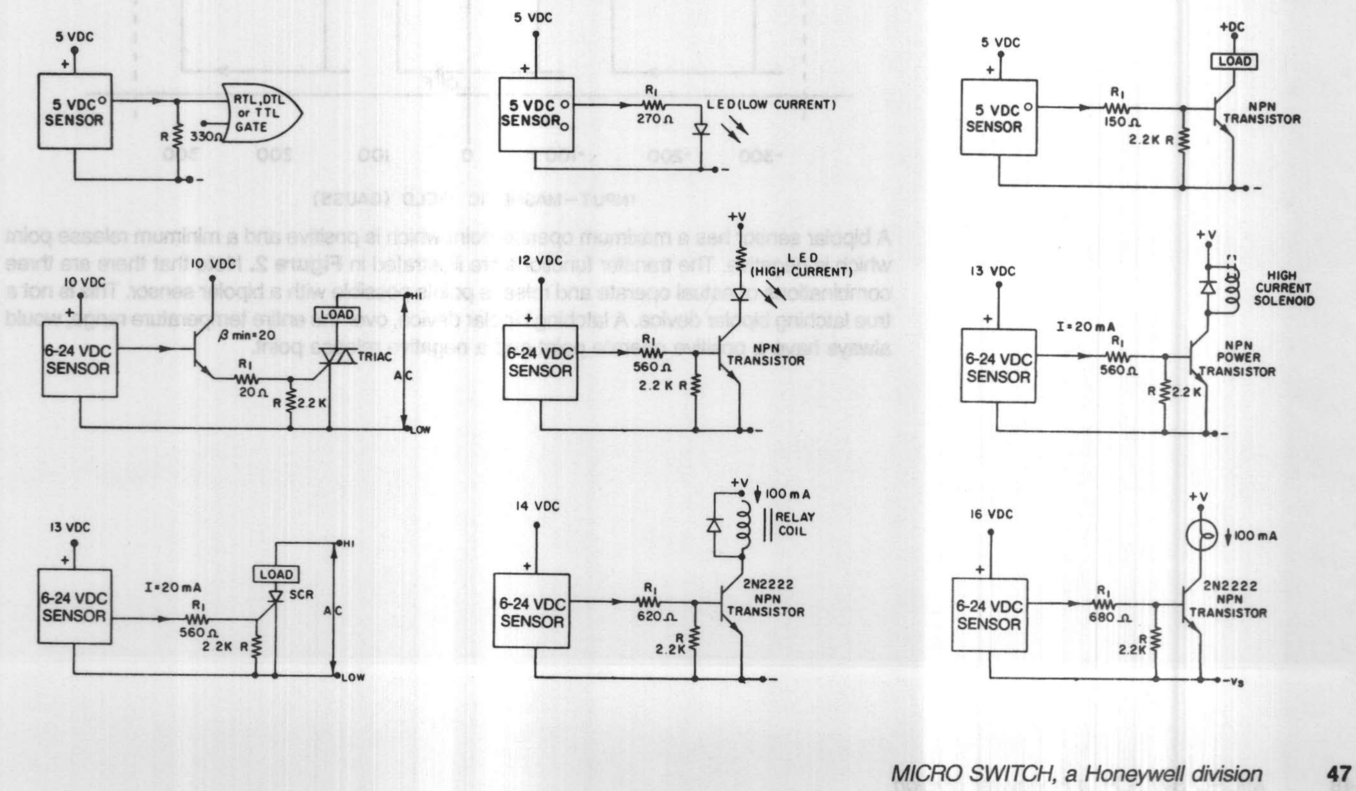


Figure 2
Current Sourcing Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.



Interpreting operating characteristics

INPUT CHARACTERISTICS

The input characteristics of a digital output Hall effect sensor are defined in terms of an operate point, release point, and differential. Since these characteristics change over temperature, and from sensor to sensor, they are specified in terms of maximum and minimum values.

Maximum operate point refers to the level of magnetic field which will insure the digital output sensor turns ON under any rated condition.

Minimum release point refers to the level of magnetic field that insures that the sensor is turned OFF.

Figure 1

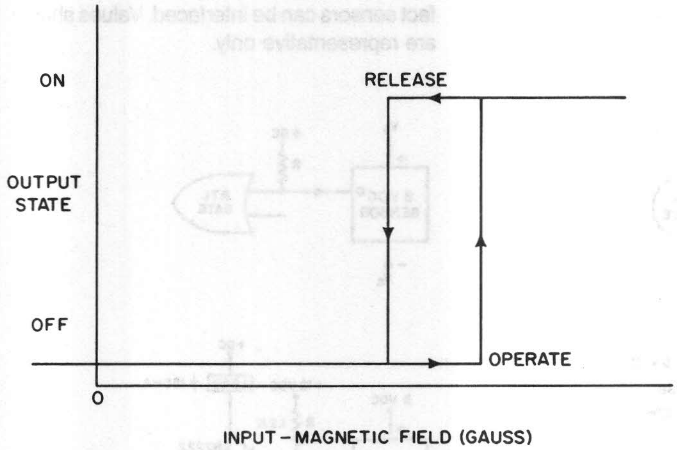
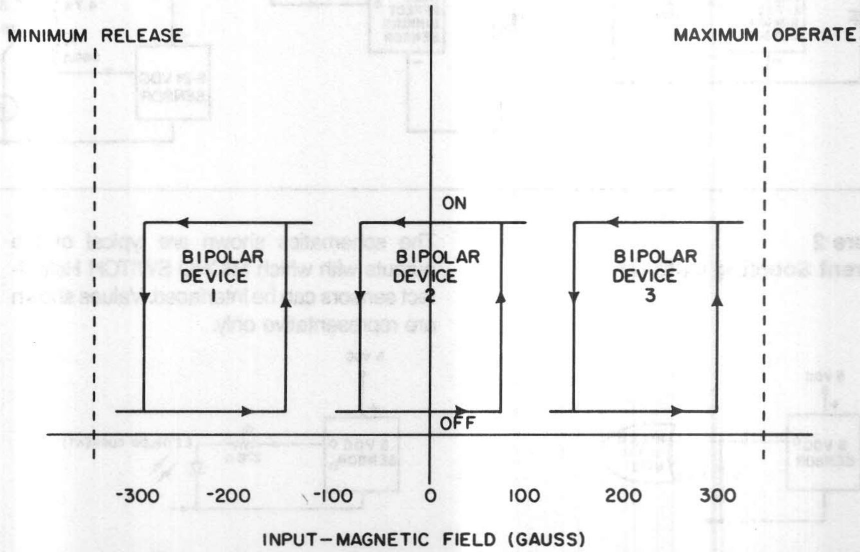


Figure 1 shows the input characteristics for a typical unipolar digital output sensor. The sensor shown is referred to as unipolar since both the maximum operate and minimum release points are positive.

Figure 2



A bipolar sensor has a maximum operate point which is positive and a minimum release point which is negative. The transfer functions are illustrated in **Figure 2.** Note that there are three combinations of actual operate and release points possible with a bipolar sensor. This is not a true latching bipolar device. A latching bipolar device, over the entire temperature range, would always have a positive operate point and a negative release point.

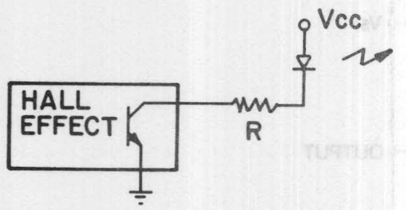
Interfacing digital Hall effect sensors

Hall effect sensors can be interfaced in many types of applications. This application note discusses the interfacing required for a few basic applications.

DRIVING AN LED INDICATOR

The simplest interface is that shown for driving an LED indicator **(Figure 1).** The resistor R must limit current through both the output transistor of the Hall transducer and the LED.

Figure 1
Driving an LED Indicator



$$R_{MN} \quad \frac{V_{CC} - V_{FLED} - V_{CE(SAT)}}{R} \quad I_{C\,MAX}$$

Where:

V_{FLED} is forward voltage drop of LED
$V_{CE(SAT)}$ is voltage drop of output transistor
$I_{C\,MAX}$ is rated current of output transistor

DIRECTION DETERMINATION

Two Hall effect sensors may be used to determine direction in a rotational application. The two are located close together, relative to the circumference of the rotating magnet **(Figure 2).** If the magnet rotates in the direction shown, the time for the South poles to pass between S1 and S2 will be short compared to the time to pass between S2 and S1. When direction is reversed, the time relationship is also reversed. **Figure 3** illustrates an implementation.

Figure 2
Rotational Direction

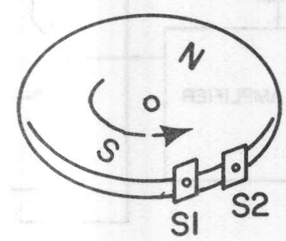
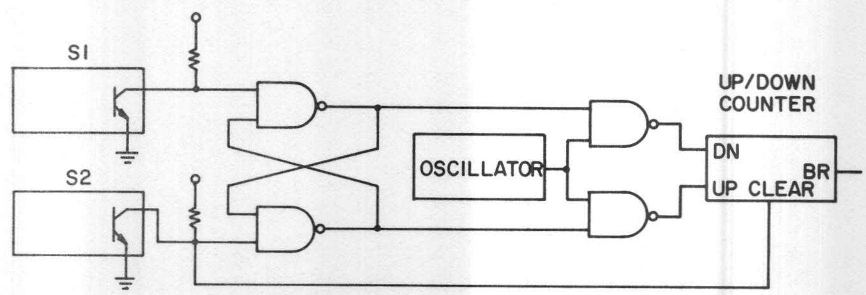


Figure 3
Up/down Counter



Starting at S2, the counter will count "up" oscillator pulses between S2 and S1, and count "down" oscillator pulses between S1 and S2. There will not be an output at the borrow terminal of the counter if the direction is as shown in **Figure 2.** If direction is reversed, there will be a pulse train out.

Hall effect transducers may also be used to control large signals and power by interfacing to a relay (**Figure 4**), an SCR (**Figure 5**), or a TRIAC (**Figure 6**). These are simple applications of the transistor interface previously discussed.

Figure 4
Relay Interface

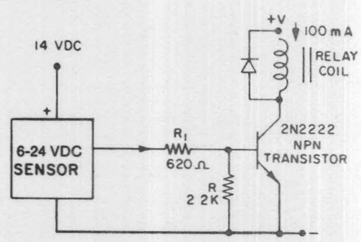


Figure 5
SCR Interface

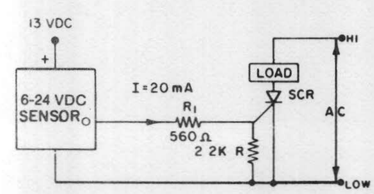
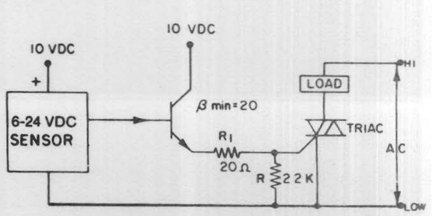


Figure 6
TRIAC Interface



Applying linear output Hall effect transducers

INTRODUCTION

The 9SS and SS9 Series Linear Output Hall Effect Transducer (LOHET™) provides mechanical and electrical designers with significant position and current sensing capabilities. Sensor characteristics and applications are discussed in this section.

SENSOR DESCRIPTION

Physical dimensions, magnetic characteristics and electrical parameters are covered on page 21.

Figure 2 presents block diagram of the 9SS. The elements which make up these transducers are: a Hall effect element, temperature compensating amplifier voltage regulation and output transistor. Three thick film resistors are incorporated in the design. Sensitivity adjustment and temperature compensation is provided with two of the resistors while the third resistor is trimmed for the offset voltage.

Figure 1
Linear Output Hall Effect Transducer (LOHET™)

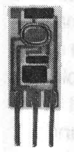
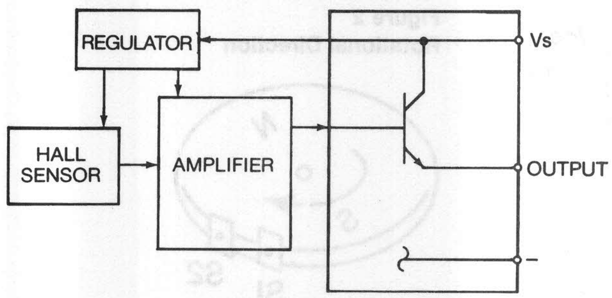


Figure 2
Block Diagram



Applying linear output Hall effect transducers

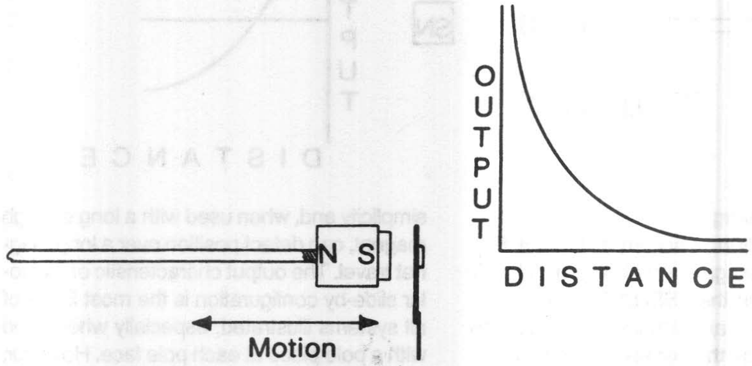
MAGNETICS

The 9SS/SS9 is magnetically actuated. **Figure 3** through **Figure 6** represent a few of the ways a magnetic system can be presented to the LOHET™ for position measurement. The method of actuation will be determined based upon cost, performance, accuracy and other requirements for a given application. The 91SS12-2 is used in these examples to provide sensor output information.

Head-on sensing

A simple method of position sensing is shown in **Figure 3.** One pole of a magnet is moved directly to or away from the 9SS. This is a unipolar head-on position sensor. When the magnet is farthest away from the sensor, the magnetic field at the sensing face is near zero gauss. In this condition, the sensor's nominal output voltage will be six volts with a 12 voltsupply. As the south pole of the magnet approaches the sensor, the magnetic field at the sensing surface becomes more and more positive. The output voltage will increase linearly with the magnetic field until a +400 gauss level or nominal output of 9 volts is reached. The output as a function of distance is nonlinear, but over a small range may be considered linear.

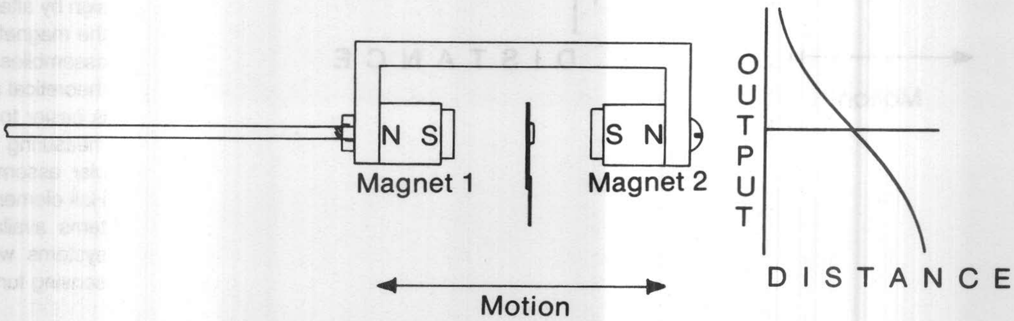
Figure 3
Unipolar Head-On Position Sensor



Bipolar head-on sensing

Bipolar head-on sensing is shown in **Figure 4.** When the magnets are moved to the extreme left, the 9SS/SS9 is subjected to a strong negative magnetic field by magnet #2, forcing the output of the sensor to a nominal 3.0 volts. As magnet #1 moves toward the sensor, the magnetic field becomes less negative, until the fields of magnet #1 and magnet #2 cancel each other, at the midpoint between the two magnets. The sensor output will be a nominal 6.0 volts. As magnet #1 continues toward the sensor, the field will become more and more positive until the sensor output reaches 9.0 volts. This approach offers high accuracy and good resolution as the full span of the sensor is utilized. The output from this sensor is linear over a range centered around the null point.

Figure 4
Bipolar Head-On Position Sensor

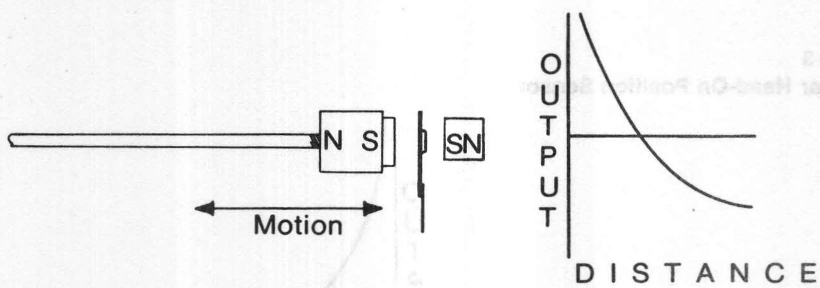


Applying linear output Hall effect transducers

Biased head-on sensing

Biased head-on sensing, a modified form of bipolar sensing, is shown in **Figure 5.** When the moveable magnet is fully retracted, the 9SS/SS9 is subjected to a negative magnetic field by the fixed bias magnet. As the moveable magnet approaches the sensor, the fields of the two magnets combine. When the moveable magnet is close enough to 9SS/SS9, the sensor will "see" a strong positive field. This approach features mechanical simplicity, and utilizes the full span of the 9SS/SS9.

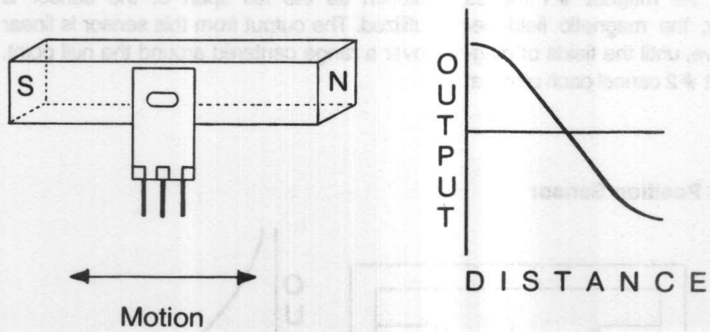
Figure 5
Biased Head-On Position Sensor



Slide-by sensing

Slide-by actuation is shown in **Figure 6.** A tightly controlled gap is maintained between the magnet and the 9SS/SS9. As the magnet moves back and forth at that fixed gap, the field seen by the sensor becomes negative as it approaches the north pole, and positive as it approaches the south pole. This type of position sensor features mechanical simplicity and, when used with a long enough magnet, can detect position over a long magnet travel. The output characteristic of a bipolar slide-by configuration is the most linear of all systems illustrated, especially when used with a pole piece at each pole face. However, tight control must be maintained over both vertical position and gap to take advantage of this system's characteristics.

Figure 6
Slide-By Position Sensor



LINEARIZING OUTPUT

The output of the sensor as a function of magnetic field is linear, while the output as a function of distance may be quite nonlinear as shown in **Figure 3.** Several methods of converting sensor output to one which compensates for the non-linearities of magnetics as a function of distance are possible. One involves converting the analog output of the 9SS/SS9 to digital form. The digital data is fed to a microprocessor which linearizes the output through a ROM look-up table, or transfer function computation techniques. A second method involves implementing an analog circuit which has the necessary transfer function to linearize the sensor's output. **Figure 7A** diagrams the microprocessor approach, and **Figure 7B** diagrams the analog circuit approach.

Figure 7A
Microprocessor Linearization

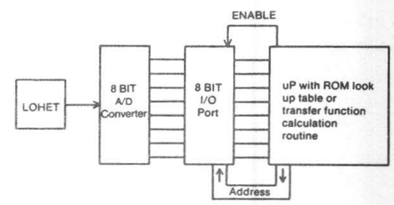
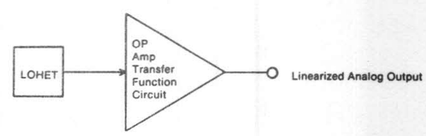


Figure 7B
Analog Linearization



A third method for linearizing the 9SS/SS9 output can be realized through magnetic design by altering the geometry and position of the magnets used. These types of magnetic assemblies are not normally designed using theoretical approaches. In most instances, it is easier to design magnetics empirically by measuring the magnetic curve of the particular assembly. By substituting a calibrated Hall element for the variety of magnetic systems available, the designer can develop systems which perform a wide variety of sensing functions.

Applying linear output Hall effect transducers

SENSOR APPLICATIONS

Liquid level measurement

Determining the height of a float is one method of measuring the level of liquid in a tank. **Figure 8** illustrates an arrangement of a LOHET and a float in a tank made of nonferrous material (aluminum). As the liquid level goes down, the magnet moves closer to the sensor, causing an increase in output voltage. This system allows liquid level measurement without any electrical connections inside the tank.

Flow meter

Figure 9 shows how LOHET could be used to make a flow meter. As the flow rate through the chamber increases, a spring loaded paddle turns a threaded shaft. As the threaded shaft turns, it raises a magnetic assembly that actuates the sensor. When flow rate decreases, the coil spring causes the assembly to lower, reducing the output. The magnetic and screw assemblies of the flow meter are designed to provide a linear relationship between the measured quantity, flow rate, and the output voltage of the sensor.

Current sensing

LOHET sensors need not be used exclusively with permanent magnets. Since the magnetic field in an unsaturated electromagnet varies linearly with current, a LOHET may be used to sense current. **Figure 10** illustrates a simple current sensor. The coil around the torroid is placed in series with the line and the sensor is placed in the gap. The magnetic field in this gap varies linearly with current, thus producing a voltage ouput proportional to the current. This type of sensor could be used in applications such as a motor control with current feedback.

The magnetic field in an electromagnet is not only a function of current, but also of the number of turns on the core. If the current to be measured is greater than 30 amperes, a single turn design can be used, such as shown in **Figure 11.** This type of sensor is particularly useful in high current systems where broad dynamic range, low series resistance, and a linear current measurement are required.

Figure 8
LOHET™ Float Height Detector

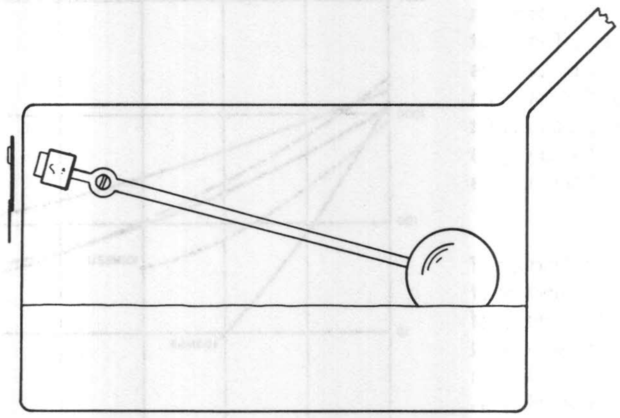


Figure 9
LOHET™ Float Meter

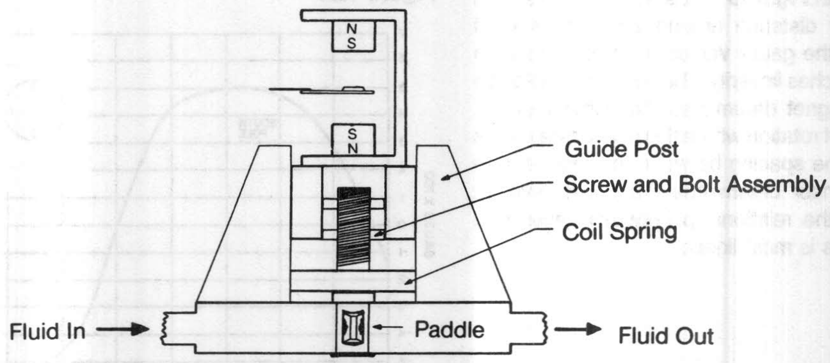


Figure 10
LOHET™ Current Sensor

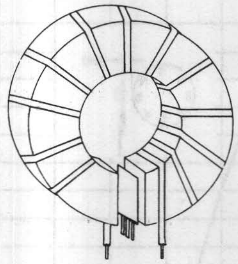
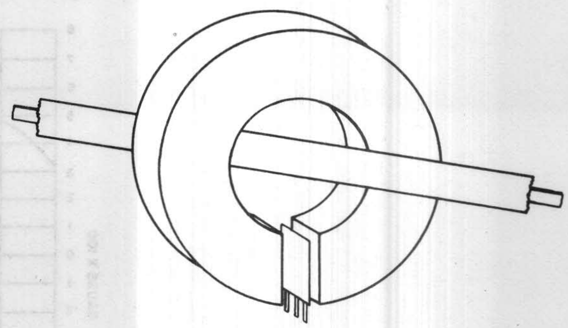


Figure 11
LOHET™ High Current Sensor



Applying linear output Hall effect transducers

Magnetics

Figure 12 is a semi-logarithmic graph of gauss versus distance for various bar magnets. Each curve is from a single magnet in the head-on mode of operation. The most stable operation at any given distance is obtained by using the magnet that provides the greatest rate of change in gauss at that distance. The best accuracy for any give magnet in the head-on mode of operation is at 400 gauss.

Although the output is linear as a function of magnetic field, it is not linear as a function of distance. Therefore, the head-on mode of operation does not provide a linear output voltage versus distance. In an application requiring use of the head-on mode of operation, a microcomputer with a look-up table can be used to convert the LOHET™ output to a linear voltage.

Gauss patterns for typical ring magnets are shown in **Figures 13A and 13B.** There is an angular distance around zero gauss level where the gauss versus degrees of rotation approaches linearity. The number of poles on the magnet determines the number of degrees of rotation where this relationship holds true. The spacing between the magnet and the sensor determines the gauss level at which the relationship between gauss and degrees is most linear.

Figure 12

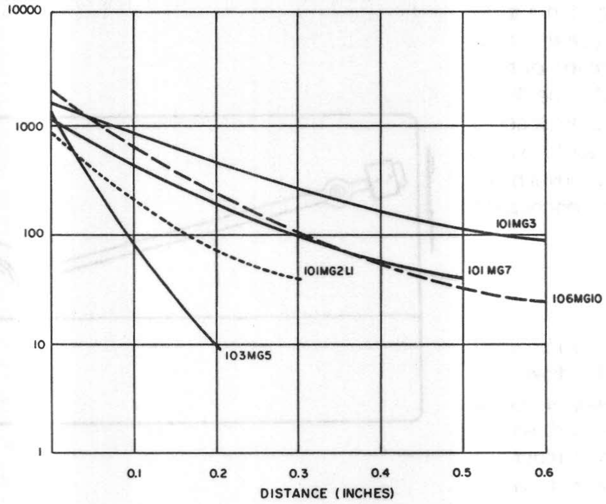


Figure 13A

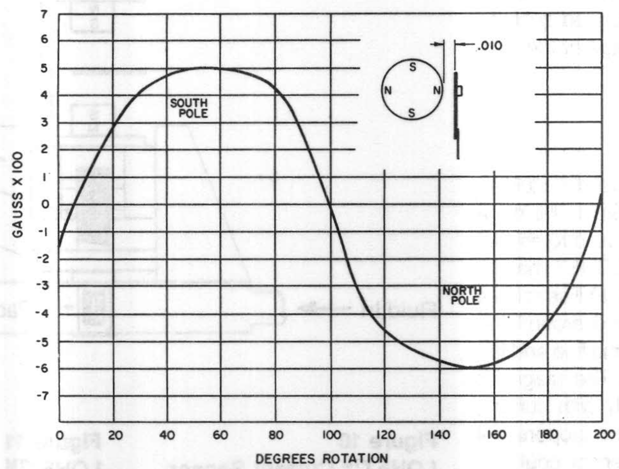
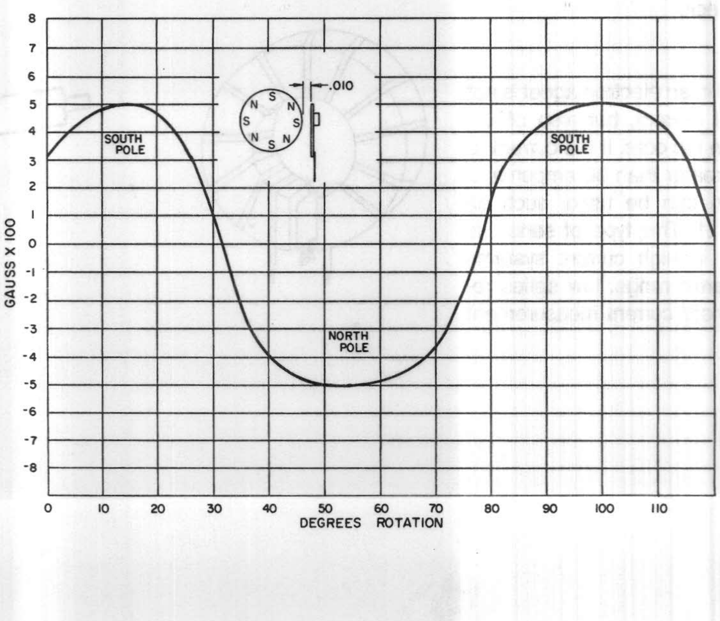


Figure 13B



Applying linear output Hall effect transducers

Figure 14 illustrates the use of two magnets to obtain a linear relationship between distance and gauss. The distance over which the relationship is most nearly linear depends on the magnets used, and the gap length between the magnets. The assembly in **Figure 14** moves perpendicularly to the LOHET™. If travel is limited to prevent the magnets from touching the LOHET™, the assembly can be used in angular measurements. Non-magnetic material such as aluminum or brass should be used for the magnet mounting bracket.

Two-magnet arrangements are also shown in **Figure 15A and 15B.** The spacing between the magnets and the LOHET™ must be held constant for repeatable operation. Curves are shown for several gap spacings between the magnets and the LOHET™. These assemblies are most useful when a high rate of change in gauss over a short travel is required.

Figure 14

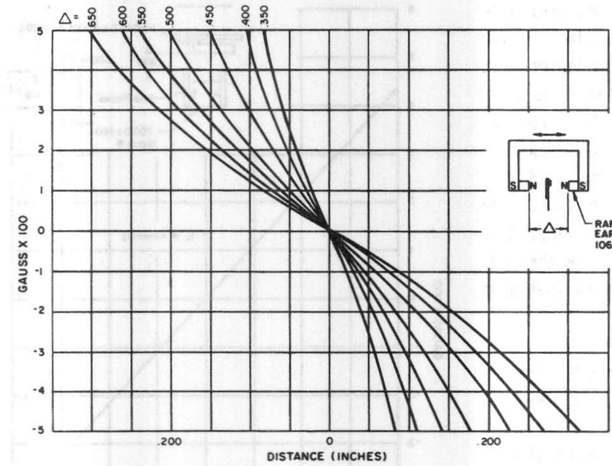


Figure 15A

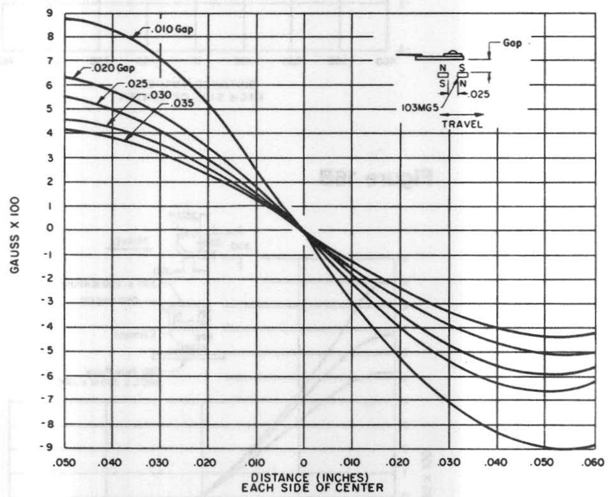
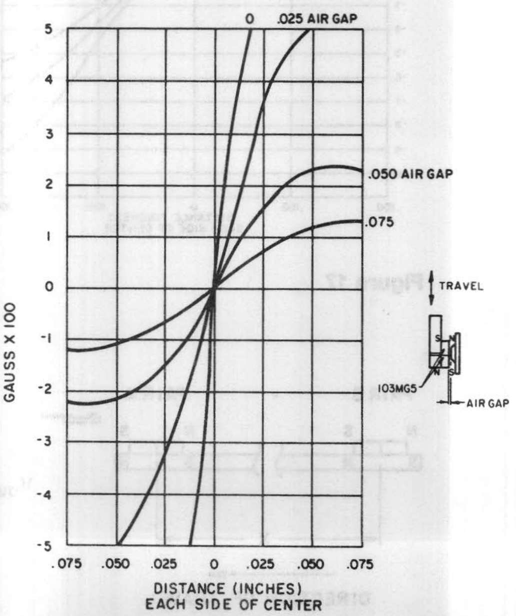


Figure 15B



APPLICATION DATA

Applying linear output Hall effect transducers

Relatively long distances with a linear relationship can be realized with the arrangement shown in **Figures 16A and 16B.** The pole piece (flux concentrator) mounted behind the LOHET™ should be equal to or greater than twice the length of the magnet. The pole pieces at each end of the magnet extend above the magnet. The area of extension is approximately 35% of the cross sectional area of the magnet. The magnet is usually 50% longer than the distance over which the linear relationship is desired. The relative sizes of the parts are shown in **Figure 16A and 16B.**

By using precisely placed magnets, the arrangements shown in **Figures 15 and 16** allow accurate measurement over a short distance when total travel is large, as shown in **Figure 17.**

Figure 16A

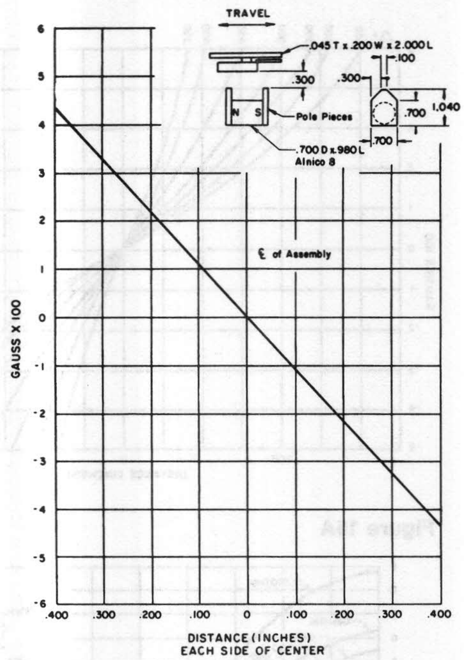


Figure 16B

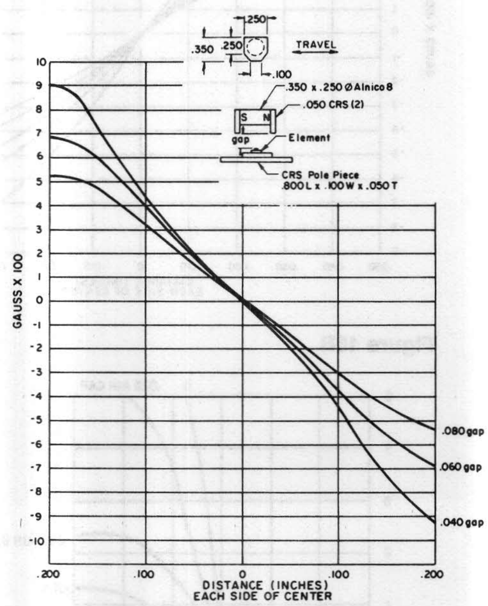
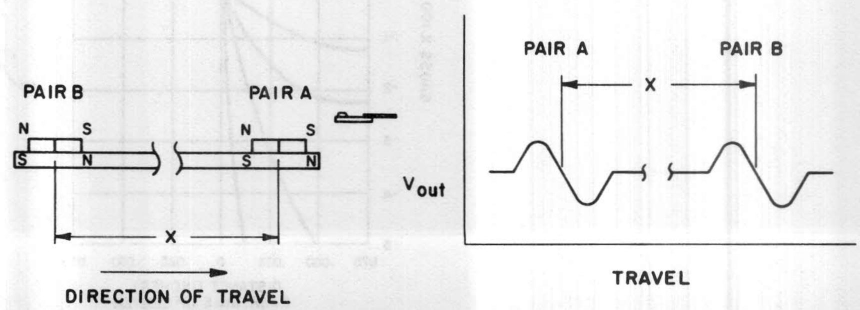


Figure 17



Applying linear output Hall effect transducers

APPLICATION

An arm is rigidly attached to a shaft that rotates 90° **(Figure 18).** The movement of the arm is rapid until it approaches the final position. Then it is to move slowly to the exact position required. A microcomputer based control system is used.

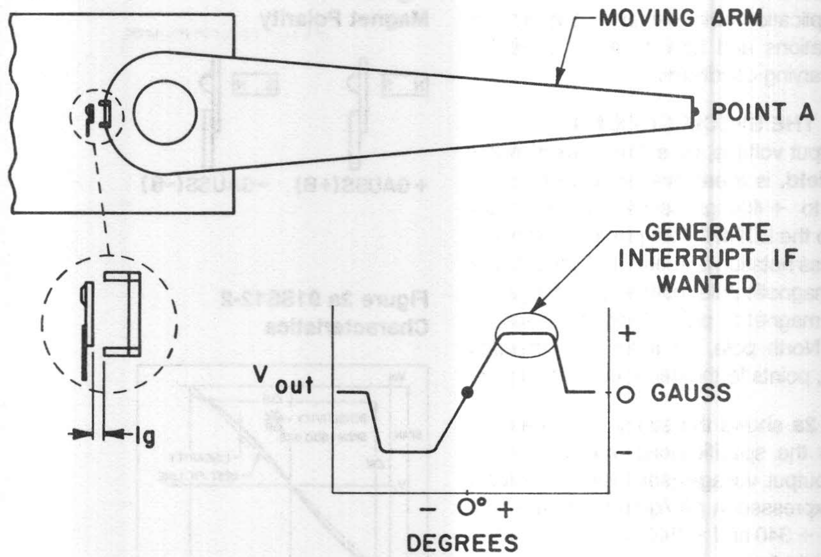
Solution

At zero gauss (center point of the magnet), the variations of Ig due to setup will not change the gauss level. When the arm rotates the full 90°, the gauss level at the LOHET™ will be zero.

1. At some time during the machine cycle, when the magnet is away from the LOHET™, read the voltage through an A/D converter (either on board the computer, or a separate device). This reading serves as the reference for this cycle.
2. Monitor the output voltage during the cycle or generate an interrupt as the zero degree point is approached.
3. When the linear region is reached, the output voltage can be converted by the microcomputer to degrees rotation or distance, as desired.
4. When the LOHET™ output voltage matches the reference from step 1, the arm is at the desired point.

This method provides continuous calibration so that any changes due to temperature variations of the A/D conversion or of the LOHET™, do not influence the measurement. An electromagnet driven by the microcomputer can be used in place of the permanent magnet.

Figure 18



APPLICATION DATA

Using 9SS/SS9 LOHET™ specifications

INTRODUCTION

This application note discusses the product specifications and how to apply LOHET™ under varying conditions.

USING THE SPECIFICATIONS

The output voltage, **as a function of magnetic field,** is linear over an input range of −400 to +400 gauss (B). Magnet orientation to the LOHET™ for positive and negative gauss notation is shown in **Figure 1.** The South magnetic pole provides positive gauss. North magnetic pole provides negative gauss. North pole, for a freely suspended magnet, points to the geographic north pole.

Figure 2a shows the straight line (dashed) used in the specifications, and the typical actual output voltage (solid line). Sensitivity (S) is expressed in mV/gauss, with the voltages at +340 and −340 gauss determining the straight line.

$$S = \frac{V_O \text{ (at } +340 \text{ gauss)} - V_O \text{ (at } -340 \text{ gauss)}}{680 \text{ gauss}}$$

Span is defined as being equal to S × 800 gauss.

Figure 2b explains linearity definitions using the end point method. Sensitivity for the SS94A1 is:

$$S = \frac{V_O \text{ (at } +500 \text{ gauss)} - V_O \text{ (at } -500 \text{ gauss)}}{1000}$$

V1 is the null offset (output voltage at zero gauss input). Linearity is the deviation in the output voltage from a straight line, expressed in percent of span. Total output voltage of any device is then $V_O = V1 + SxB$.

Note: With ratiometric devices, span, null and sensitivity must be calculated if the supply voltage is other than the 12V used to establish the specifications. For example, 91SS12-2, operated at 9 volts.

Span $= \frac{9}{12} \times 6V = 4.5V$ where $\frac{9}{12}$ is the supply voltage ratio.

Null $= \frac{9}{12} \times 6V = 4.5V$ where

Sensitivity $= \frac{9 \text{ (7,5mV/gauss)}}{12} = 5.625$ mV/gauss

Note: The SS94A1 will clamp at 9.0V min. (9.5V typical).

Figure 3 shows the possible changes in null offset (V1) due to changes in ambient temperature. The initial value of V1 can be modified by external circuitry (provided by the customer). Variations in null offset effectively move the total curve in **Figure 2** up or down.

Figure 1
Magnet Polarity

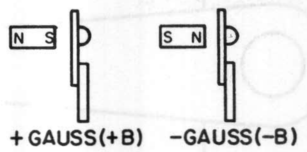


Figure 2a 91SS12-2 Characteristics

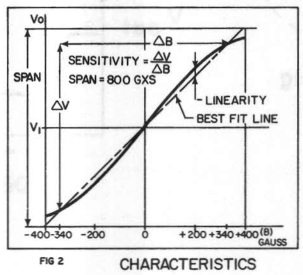


Figure 2b SS94A1

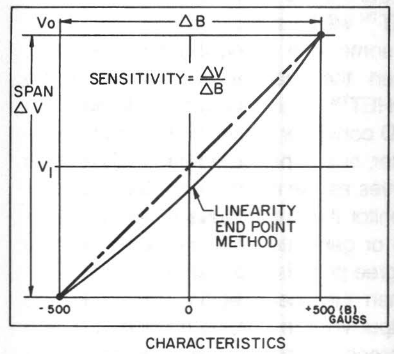
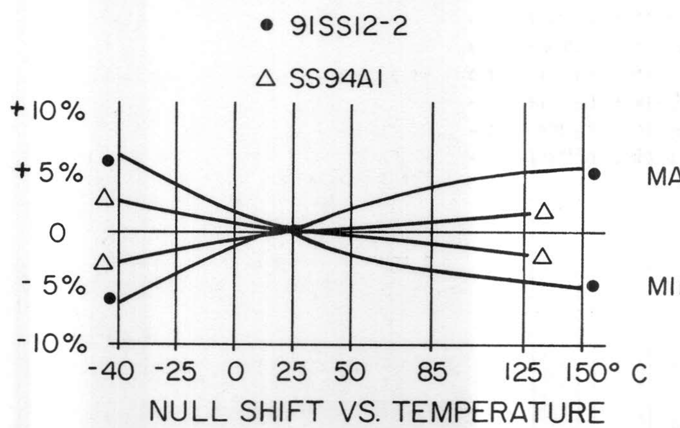


Figure 3
Null Shift vs. Temperature



Using 9SS/SS9 LOHET™ specifications

Figure 4 compares output voltages with various values of gauss and sensitivity. The null tolerances must be added to get total span tolerance. **Figure 5** shows the effects of the total temperature range on sensitivity as a percentage change from initial value.

Linearity for 91SS12-2, as given in the specifications, is the deviation from the expected straight line as determined by readings at −340 gauss and +340 gauss. This ensures a best fit straight line for applications using a bipolar magnet, or an AC signal. In unipolar magnetic applications, the linearity tolerance at any given level of B will be higher, since the zero gauss level is not used in specifying linearity. In these applications, the tolerance should be increased by 50%. **Figure 6** shows linearity characteristics (worst case). The linearity tolerance is specified as a percentage of span.

Linearity as defined for the SS94A1 **(Figure 2b)** is determined by the end points at −500 and +500 gauss. As shown linearity is +0 −1% using this method. If we were to define linearity for this product using a best fit line it would be ±.5%.

Figure 7 illustrates a method of plotting characteristics for a typical position sensing application making the following assumptions:

1. The 91SS12-2 ratiometric listing is used.
2. Input voltage = 12VDC.
3. An external comparator (customer supplied) is used to adjust operate point.
4. Temperature range is +15°C to +50°C.
5. Operating point at 25°C is +300 gauss only.

Figure 4
Output Voltage Comparison

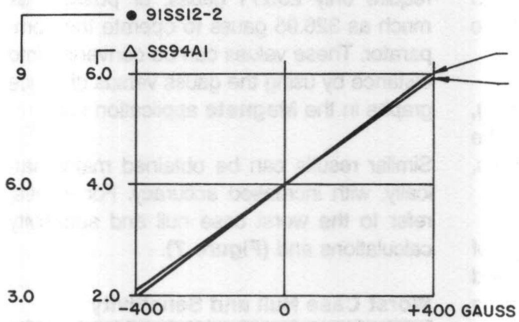


Figure 5
Max Sensitivity Change vs. Temperature

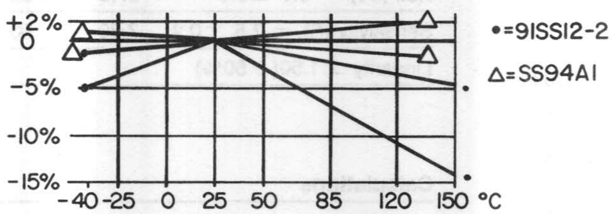


Figure 6
Linearity Tolerance vs.Gauss

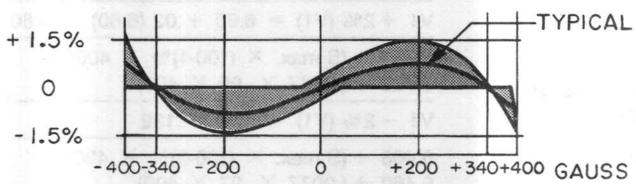
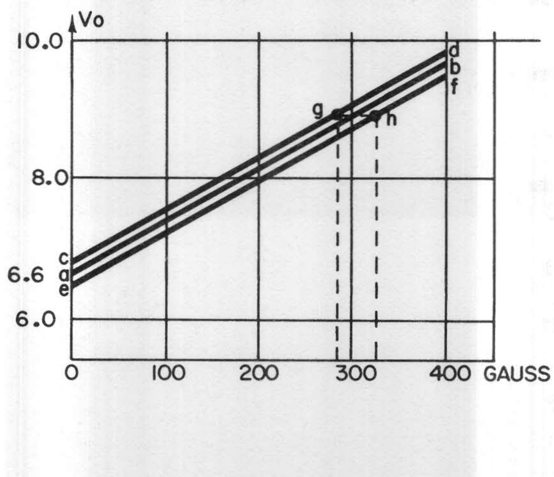


Figure 7
Typical Characteristics Plot



APPLICATION DATA

Using 9SS LOHET™ specifications

You need to know the worst case gauss limits (minimum and maximum) with temperature change. Calculate characteristics at 12VDC at 25°C and at 50°C (changes at 15°C will be minimal).

If you are drawing a large graph **(Figure 7)**, linearity changes can now be added. The result will be a slight curve in all three lines, with a net effect close to zero.

Line g-h indicates the operating voltage of the external circuit. Points g (285 gauss) and h (327 gauss) are the worst case operating points at 50°C.

Find worst cast gauss (minimum):

S = S max. at 25°C S′ = S max. at 50°C

B = Op. gauss at 25°C B′ = Op. gauss at 50°C

$$V1 + S \times B = V1 + \triangle V1 + S \times B$$

$$\frac{V1 + S \times B - V1 - \triangle V1}{S'} = B'$$

$$\frac{S \times B - \triangle V1}{S'} = B'$$

$$\frac{(7.70\text{mV/gauss} \times 300) - (6.60 \times 2\%)}{7.70\text{mV/gauss} \times (100\text{-}1)\%} = B'$$

$$\frac{(.0077 \times 300) - (6.60 \times .02)}{.0077 \times .99} = B'$$

$$\frac{2.31 - .132}{.007623} = 285.71 \text{ gauss (minimum)}$$

Find worst case gauss (maximum):

S = S max. at 25°C S″ = S min. at 50°C

B = Op. gauss at 25°C B″ = Op. gauss at 50°C

$$V1 + S \times B = V1 - \triangle V1 + S \times B$$

$$\frac{V1 + S \times B - V1 + \triangle V1}{S''} = B''$$

$$\frac{S(B) + \triangle V1}{S''} = B''$$

$$\frac{(7.70\text{mV/gauss} \times 300) + (6.60 \times 2\%)}{7.70\text{mV/gauss} \times (100\text{-}3)\%} = B''$$

$$\frac{(.0077 \times 300) + (6.60 \times .02)}{.0077 \times .97} = B''$$

$$\frac{2.31 + .132}{.007469} = 326.95 \text{ gauss (maximum)}$$

The shift in gauss (both minimum and maximum) means that at 50°C, the 9SS may require only 285.71 gauss, or possibly as much as 326.95 gauss to operate the comparator. These values can be converted into distance by using the gauss versus distance graphs in the **Magnets** application note.

Similar results can be obtained mathematically, with increased accuracy. For values, refer to the worst case null and sensitivity calculations and **(Figure 7)**.

Worst Case Null and Sensitivity

	at 25°C				
	Min.	**Typ.**	**Max.**	**at 50°C**	**Units**
Null (V1) = 6.0 ±0.6	5.40	6.00	6.60	±2%	Volts
Sensitivity (S) = 7.5 ±0.2	7.30	7.50	7.70	−1% to −3%*	mV/gauss
Linearity ±1.50(+50%)			±2.25	±2.25	%

Calculations

	Point	**Value**	**°C**
Null offset (max.) at zero gauss (V1)	a	6.60	25
V1 +S max. × 400 = 6.60 +3.08	b	9.68	25
V1 +2% (V1) = 6.60 +.02 (6.60) = 6.60 +0.132	c	6.732	50
6.732 +(S max. × (100-1)% × 400) = 6.732 +(.0077 × .99 × 400)	d	9.7812	50
V1 −2% (V1) = 6.60 −.132	e	6.468	50
6.468 +(S max. × (100-3)% × 400) = 6.468 +(.0077 × .97 × 400)	f	9.4556	50

* Sensitivity shift at 0°C to 50°C, the typical value (−0.077%/°C) is specified. Actual range is somewhere between −1% and −3%. For accuracy in calculations, both limits are used (−1% and −3%). (50° −25°C)+(−0.077%/°C)= −1.925%

Interfacing the 9SS/SS9 LOHET™ with comparators and OP amps

INTRODUCTION

This application note covers some common comparator and op amp circuits and their interface with LOHET™. IC manufacturers specification sheets should be consulted when choosing the best op amp or comparator for your application.

Resistor tolerances and temperature co-efficients influence overall accuracy. The load resistor (RL) however, is not critical. A ±10% carbon resistor is satisfactory. The load resistor on the LOHET™ output insures that the load is the same as that used during LOHET™ manufacture.

COMPARATORS

Figure 1 through **Figure 4** show typical comparator circuits. A single supply LM339 (or equivalent) is used to make a digital switch with adjustable operate point. Hysteresis is provided by resistor RH. In **Figures 1 and 2,** hysteresis is essentially zero, but can be made large enough to provide a latching circuit. By-pass capacitors may be required in some applications, but are not shown on these circuits. The LM339 can provide up to four different switch points per LOHET™. If linear use and digital operation with one LOHET™ is required, an LM124 (or equivalent) op amp may be substituted.

OP AMPS

Figure 5 through **Figure 9** show the LOHET™ interfaced with common single supply op amp circuits. Op amp characteristics limit the output voltage (Vo) equations at high and low ends. The basic circuits can be modified and inter-connected (see **Figures 10 and 11**).

The circuit in **Figure 5** can be used with adjustable gain and adjustable offset, although the adjustments will not be completely independent. One method is to adjust the gain to the desired value V1 at approximately one-half Vs. Then, adjust V1 to give the exact offset at Vo required for the application.

Figure 10 illustrates possible gain adjustment by R2 for desired voltage at V2. R5 is then adjusted to provide the desired offset at Vo. Adjustable R values can be provided by potentiometers, fixed resistor combinations, or by laser trimmed thick film resistors.

The basic op amp circuits or circuit combinations will fulfill most LOHET™ use requirements. AC coupling is not shown, but can be used to ground reference AC levels out of the LOHET™. Op amp application data sheets can be obtained from semiconductor suppliers.

Figure 1
Non-inverting

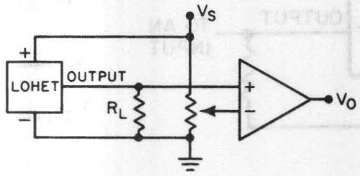


Figure 2
Inverting

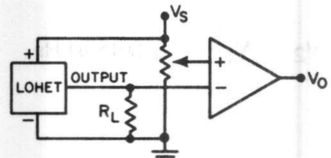


Figure 3
Non-inverting with Hysteresis

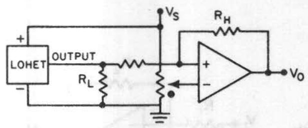


Figure 4
Inverting with Hysteresis

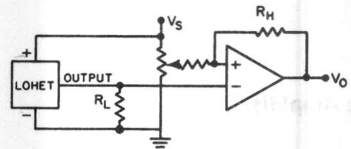
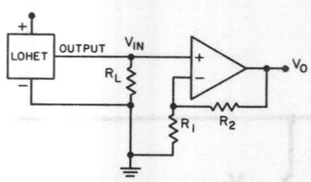
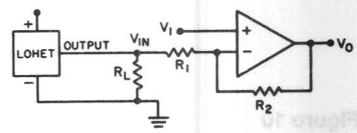


Figure 5
Non-inverting



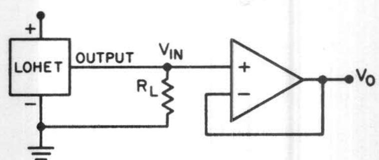
$$Vo = (V_1 - V_{IN})\frac{R_2}{R_1} + V_1$$

Figure 6
Inverting



$$Vo = V_{IN}\,(1 + \frac{R_2}{R_1})$$

Figure 7
Voltage Follower



Interfacing the 9SS/SS9 LOHET™ with comparators and OP amps

Figure 8
Summing Amplifier with LOHET™ as any Input

$V_O = V_1 + V_2 - V_3 - V_4$ (with all Rs equal)

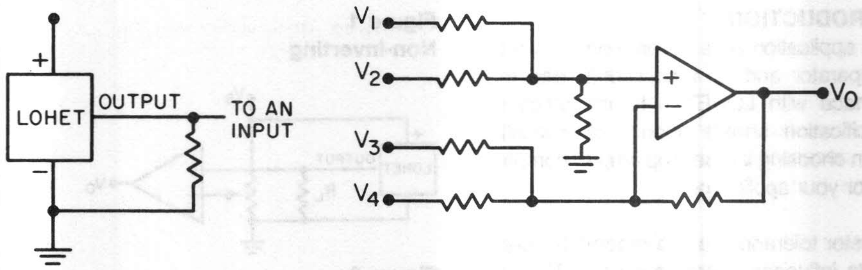


Figure 9
Difference Amplifier

For $R_1 = R_3$ and $R_2 = R_4$,

$$V_O = \frac{R_2}{R_1}(V_{IN} - V_1)$$

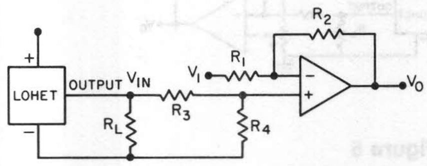


Figure 10
Independent Gain and Offset Adjustments

$$V_2 = (V_1 - V_{IN})\frac{R_2}{R_1} + V_1$$

$$V_O = (V_3 - V_2)\frac{R_4}{R_3} + V_3$$

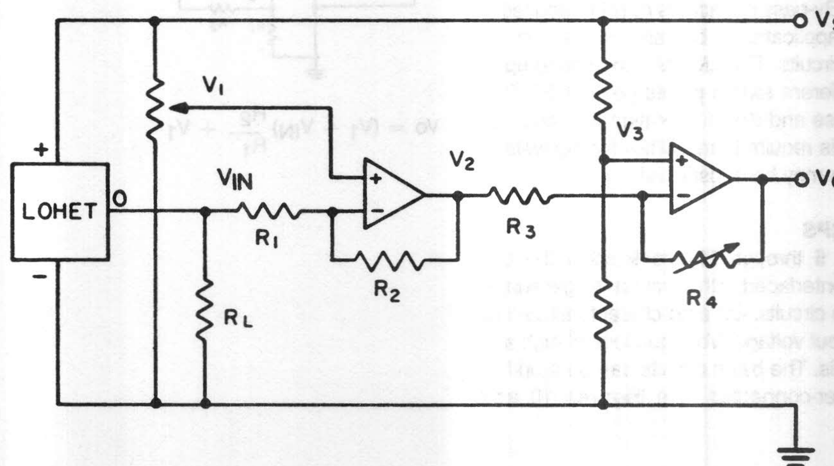
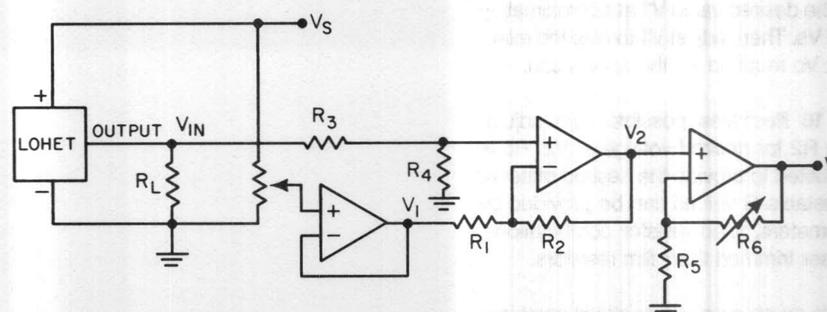


Figure 11
Independent Gain and Offset Adjustments

For $R_1 = R_2 = R_3 = R_4$,

$$V_O = (V_{IN} - V_1)\left(1 + \frac{R_6}{R_5}\right)$$



Interfacing the 9SS/SS9 LOHET™ with comparators and OP amps

TEMPERATURE DRIFT COMPENSATION

LOHET™ temperature stability meets most application requirements. Occasionally, however, an application requires extremely tight characteristics. Sorting at use temperature is then necessary. **Figure 12** illustrates a simple method of checking null shift.

Use the same Vs, load and temperature as will be used in the actual application. Set the potentiometer so that the voltmeter reads zero when the LOHET™ is in the 25°C socket. Then move the LOHET™ to the T2 socket, transfer the switch contacts and simply read the null shift directly from the voltmeter. The physical setup is adequate for most requirements.

When null offset temperature drift is known, compensation can be added to the comparator or op amp circuit to temperature stabilize the entire circuit. A thermistor or op amp multiplication of a VBE drop can be used. A VBE multiplier **(Figure 13)** serving as one of the inputs to a summing amplifier is another method.

If sensitivity drift must also be compensated, then measurements must be taken at the use temperature with an applied magnetic field. The number of fixtures required depends on how many different gauss level measurements are needed, and on the number of different temperatures encountered in the application. **Figure 14** shows a simplified drawing of a fixture that can be used for taking these measurements.

Figure 12

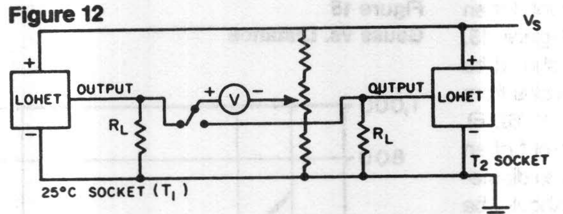


Figure 13

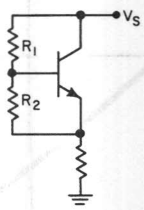
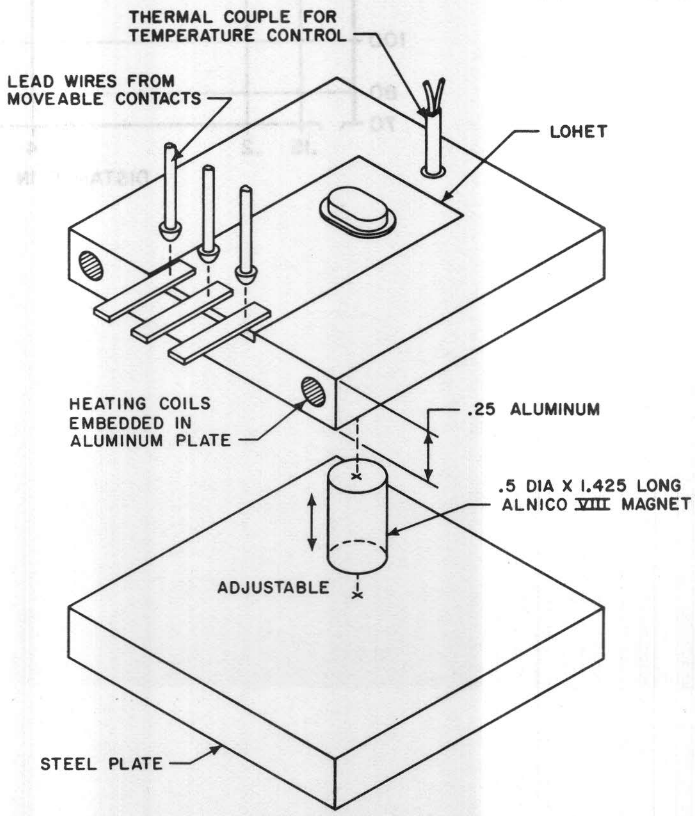


Figure 14

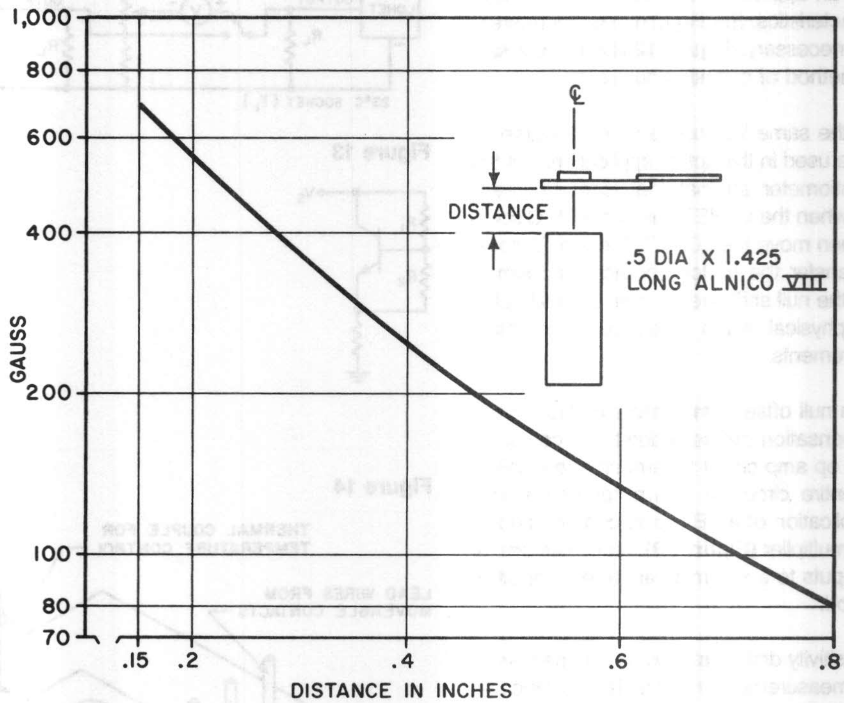


Interfacing the 9SS/SS9 LOHET™ with comparators and OP amps

A typical gauss versus distance graph for an Alnico VIII magnet is shown in **Figure 15.** The magnets used in the fixtures should be temperature cycled at least two cycles from −60°C to +200°C (−76°F to +362°F). Thereafter, the temperature coefficient of an Alnico VIII magnet (with the length to diameter ratio shown in **Figure 15**) should be ±.003%/°C. Calibration and adjustments should be made using a Calibrated Hall Element as a substitute for the LOHET. A steel plate below the magnet prevents differences in bench material from influencing the fixture calibration.

Once gain characteristics of a given device or group of devices are known, compensation can be added to the op amp circuit. Common methods are a temperature varying voltage into a summing amp, or a temperature variable resistance as part of the gain determining portion of the op amp configuration.

Figure 15
Gauss vs. Distance



Magnets

MICRO SWITCH supplies bar and ring magnets for operating Hall effect sensors. The most common form of magnet is the bar magnet which can be used to operate any Hall effect sensor.

Ring magnets are magnetized on the outside diameter with alternating north and south poles. Each pole pair (N and S) produces one pulse with standard Hall effect devices. Ring magnets are particularly useful with bipolar sensors, which require both south and north poles be presented to the sensor face. (See **Glossary of terms** for definition of bipolar, omnipolar and unipolar.)

MAGNET SELECTION GUIDE

This guide is designed to aid in determining the best magnet for use with a Hall effect sensor. There are several factors to consider when choosing a magnet. The most important is gap distances. There must be adequate magnetic gauss to operate the sensor at the correct distance. By using the maximum operate magnetic gauss characteristics (see sensor order guides), you can determine which magnet(s) will operate the sensor. Other important factors include temperature range and the physical environment of the application.

Material and Process	Physical Strength	Temperature Range*	Magnetic Shock Resistance	Resistance To Demagnetization	Gap Distance** & Gauss Level @ 25°C 0,25 .010	0,76 .030	1,27 .050	2,54 .100	3,81 .150	5,08 .200	Catalog Listing
Alnico V Cast	Good	– 40 to 300°C	Poor	Fair	1460	1320	1170	810	575	420	**101MG3**
Alnico VIII Sintered	Good	– 40 to 250°C	Good	Excellent	1050	900	755	470	295	195	**101MG7** **102MG11** **102MG15**
Alnico VI Sintered	Good	– 40 to 250°C	Good	Good	730	550	410	205	115	75	**101MG2L1**
Indox 1 Pressed	Good	0 to 100°C	Good	Excellent	700	520	375	175	85	45	**105MG5R2** **105MG5R4**
Rare Earth Pressed	Poor	– 40 to 250°C	Good	Excellent	1110 2620 2620	630 2100 2100	365 1600 1600	120 940 940	55 550 550	25 350 350	**103MG5** **106MG10** **103MG8**

*Magnet will not be damaged over temperature range.
**Gap distance from Hall element.

Magnets

MAGNET MANUFACTURERS

Listed at right are magnet manufacturers and some of their product offerings. They should be consulted for specific data on a magnet or material, as well as magnet design assistance.

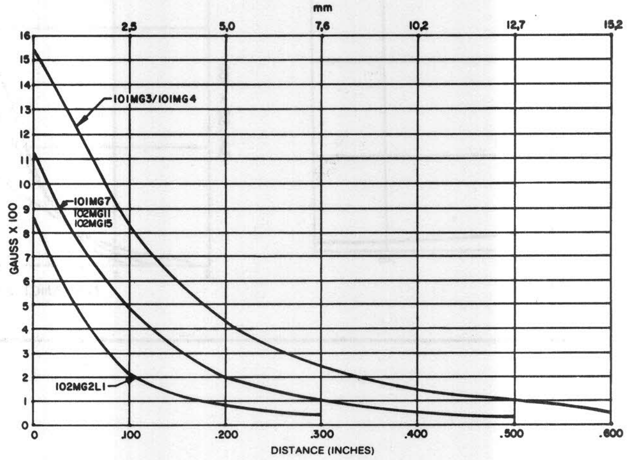
Manufacturer	Magnet Type
Arnold Engineering Marengo, IL 61052 815/568-2000	Ceramic Barium Ferrite, Alnico or equiv.
Plastics Extrusions Div., GenCorp. Inc. Evansville, IN 47710	Plastic Barium Ferrite
Hitachi Magnetics Corp. Edmore, MI 48829 517/427-5151	Ceramic Barium Ferrite, Rare Earth, Alnico or equiv.
Temgam Engineering, Inc. Otsego, MI 49078	Plastic Barium Ferrite
Crucible Magnetics Div., Colt Ind. Chicago, IL 60639	Rare Earth, Alnico or equiv.
Webster Hoff Glendale Heights, IL 60137	Plastic Barium Ferrite
3M Company St. Paul, MN 55101 800/328-1373	Plastic Barium Ferrite
Bovee Engineering Sales Co., Inc. Wheaton, IL 61087	Plastic Barium Ferrite Rare Earth
Ceramic Magnetics Fairfield, NJ 07006 201/227-4222	Rare Earth
TDK Corporation of America Chicago, IL 60659 312/803-6100	Ceramic Barium Ferrite Rare Earth

Distributor	Type
Permag 516/822-3311 Atlanta, GA 30301 Billerica, MA 01821 Eden Prairie, MN 55344 Elk Grove Village, IL 60007 Hicksville, NY 11802 Los Alomitos, CA 90720 Richardson, TX 75080 Sunnyvale, CA 94088 Toledo, OH 43601	Magnets, toroids, etc.

MAGNET CURVES
The curves shown on the graphs are typical plots of induction (gauss) versus distance for various magnets. For more information, contact your nearest MICRO SWITCH sales office.

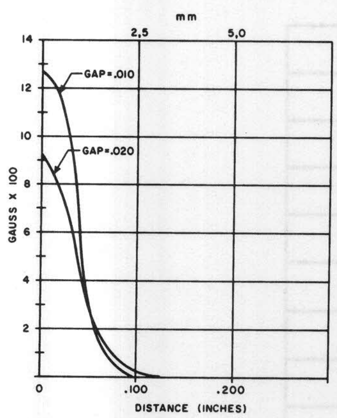
Magnet:
101MG3, 101MG7, 102MG11, 102MG15
101MG2L1

Mode of Operation:
Head-on



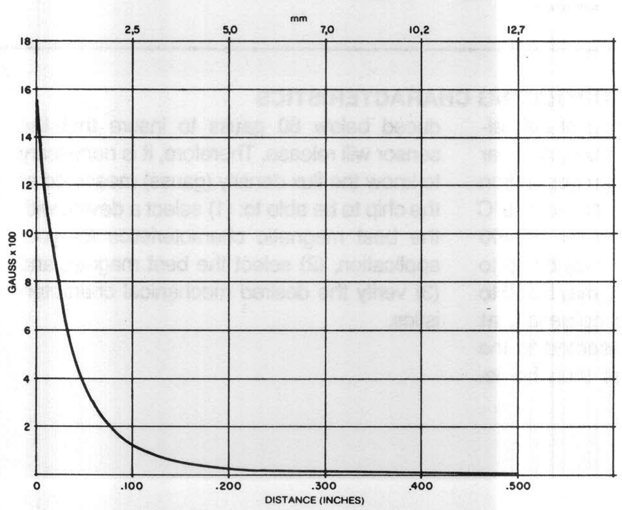
Magnet:
103MG5

Mode of Operation:
Slide-by



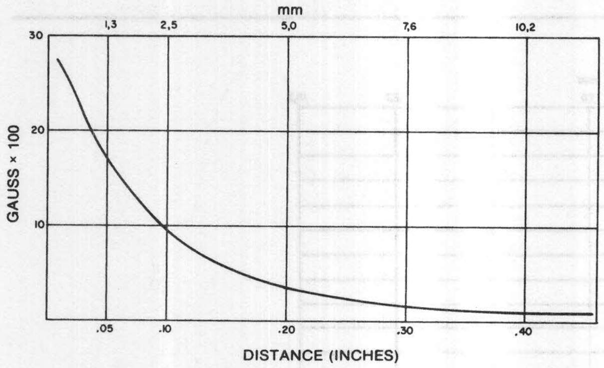
Magnet:
103MG5

Mode of Operation:
Head-on

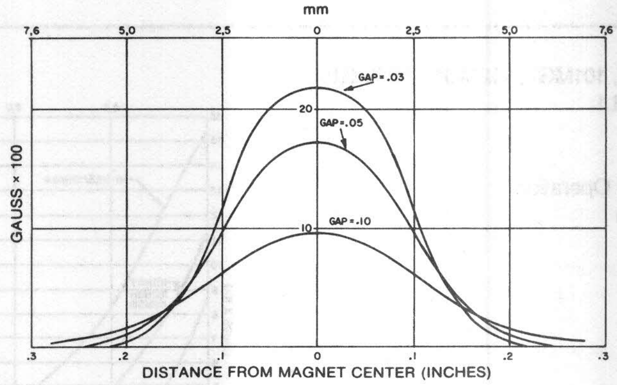


Magnets

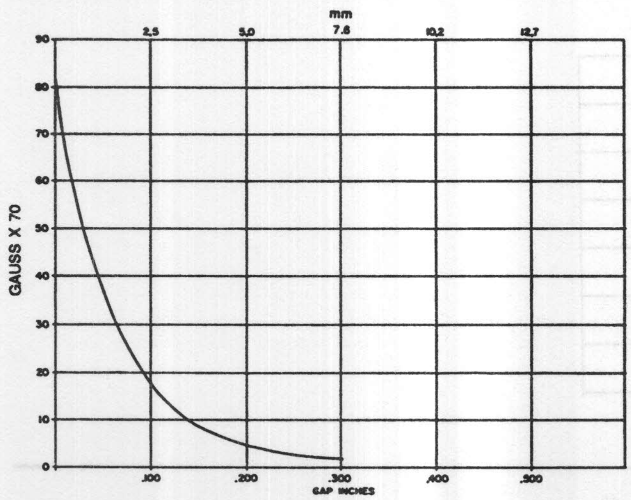
Magnet:
106MG10, 103MG8
Mode of Operation:
Head-on



Magnet:
106MG10, 103MG8
Mode of Operation:
Slide-by



Ring magnet:
105MG5R4
Measured with:
732SS21-1 Calibrated Hall Element
Gap length characteristic at South pole.



DETERMINING MAGNETIC OPERATING CHARACTERISTICS

Magnetic sensing characteristics of Hall effect sensors are specified within particular ranges. For example, assume an application with a temperature range of −40° to 125°C using an SS443A. Referring to the SS400 Order Guide, the operate point may be up to 215 gauss and the release point may be 60 to 190 gauss. To insure reliable operation, **at least** 215 gauss must be presented to the sensor. The gauss level must then be reduced below 60 gauss to insure that the sensor will release. Therefore, it is necessary to know the flux density (gauss) measured at the chip to be able to: (1) select a device with the best magnetic characteristics for your application, (2) select the best magnet, and (3) verify the desired mechanical characteristics.

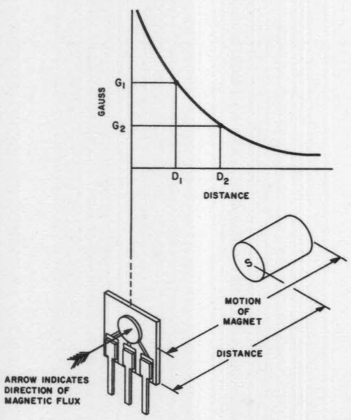
Method of magnet actuation

There are many ways to apply Hall effect in position sensing application. The more common methods are described below. Further information is as near as your telephone. Just call your nearest MICRO SWITCH sales office and one of our trained field engineers will be happy to discuss your application with you.

Head-on

For "head-on" actuation, there should be sufficient magnet travel to provide at least 10% flux overdrive of both maximum operate and minimum release characteristics of the sensor. The target is centered over the point of maximum sensitivity and is moved "head-on" to the sensor, then backed off.

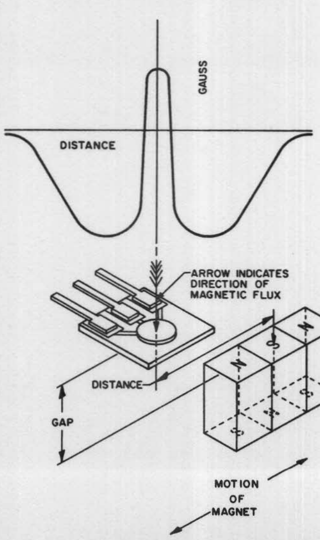
Unipolar Head-on



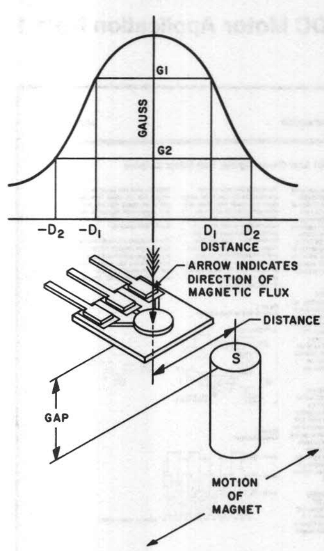
Slide-by

For "slide-by" actuation, the magnet should pass the sensing surface at a distance which provides at least 10% flux overdrive above maximum operate. The target is moved across the face of the sensor at a specified distance.

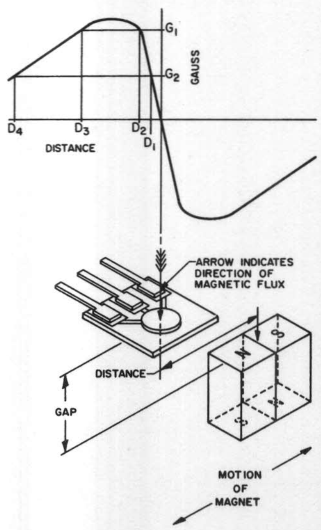
Bipolar Slide-by (3 Magnets)



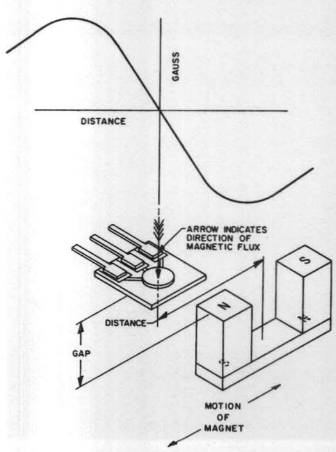
Unipolar Slide-by



Bipolar Slide-by (1 Magnet)



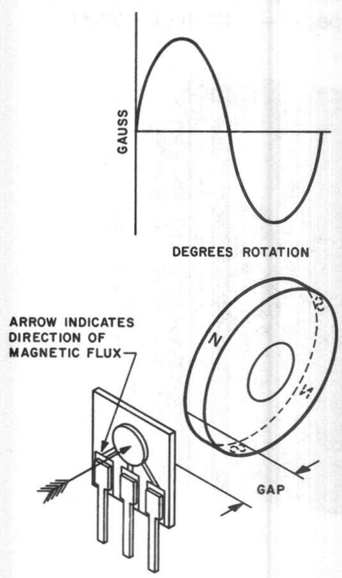
Bipolar Slide-by (2 Magnets)



Rotary

A rotating target, such as a ring magnet, provides an alternating pattern of On-Off actuation.

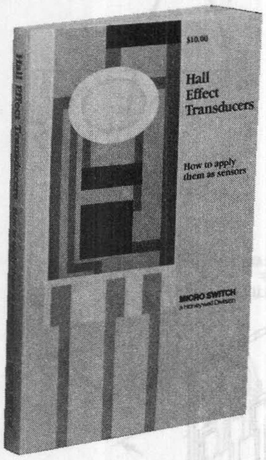
Bipolar Slide-by (Ring Magnet)



Available solid state sensor literature

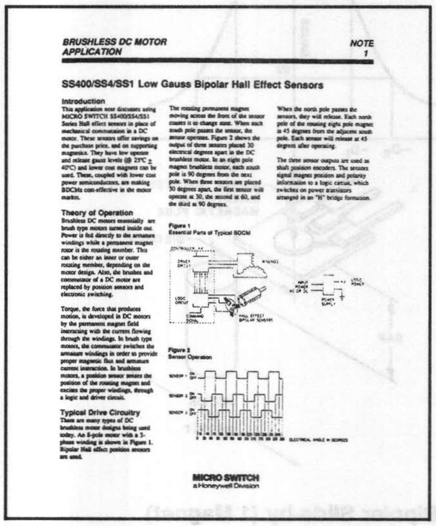
Hall Effect Transducers —
How to apply them as sensors

The first part of the book presents the basic information needed to apply Hall effect sensors. The last two chapters bring this information together and relate it to the design and application of Hall effect sensing systems. 280 pages — $10.00 (84-05715)



Application Notes:

Brushless DC Motor Application Note 1
(84-05759)



BRUSHLESS DC MOTOR APPLICATION ***NOTE 1***

SS400/SS4/SS1 Low Gauss Bipolar Hall Effect Sensors

Introduction
This application note discusses using MICRO SWITCH SS400/SS4/SS1 Series Hall effect sensors in place of mechanical commutation in a DC motor. These sensors offer savings on the purchase price, and on supporting magnetics. They have low operate and release gauss levels (@ 25°C ± 40°C) and lower cost magnets can be used. These, coupled with lower cost power semiconductors, are making BDCMs cost-effective in the motor market.

Theory of Operation
Brushless DC motors essentially are brush type motors turned inside out. Power is fed directly to the armature windings while a permanent magnet rotor is the rotating member. This can be either an inner or outer rotating member, depending on the motor design. Also, the brushes and commutator of a DC motor are replaced by position sensors and electronic switching.

Torque, the force that produces motion, is developed in DC motors by the permanent magnet field interacting with the current flowing through the windings. In brush type motors, the commutator switches the armature windings in order to provide proper magnetic flux and armature current interaction. In brushless motors, a position sensor senses the position of the rotating magnet and excites the proper windings, through a logic and driver circuit.

Typical Drive Circuitry
There are many types of DC brushless motor designs being used today. An 8-pole motor with a 3-phase winding is shown in Figure 1. Bipolar Hall effect position sensors are used.

The rotating permanent magnet moving across the front of the sensor causes it to change state. When each south pole passes the sensor, the sensor operates. Figure 2 shows the output of three sensors placed 30 electrical degrees apart in the DC brushless motor. In an eight pole magnet brushless motor, each south pole is 90 degrees from the next pole. When three sensors are placed 30 degrees apart, the first sensor will operate at 30, the second at 60, and the third at 90 degrees.

When the north pole passes the sensors, they will release. Each north pole of the rotating eight pole magnet is 45 degrees from the adjacent south pole. Each sensor will release at 45 degrees after operating.

The three sensor outputs are used as shaft position encoders. The sensors signal magnet position and polarity information to a logic circuit, which switches on power transistors arranged in an "H" bridge formation.

Figure 1
Essential Parts of Typical BDCM

Figure 2
Sensor Operation

MICRO SWITCH
a Honeywell Division

Magnetic conversion chart

MULTIPLICATION FACTORS

From	Gauss	Tesla	Millitesla	Weber/Inch^2	Weber/Meter^2	Line/Inch^2	Gammas
To:							
Gauss	1	1×10^{4}	10.0	1.550×10^{7}	1×10^{4}	1.55×10^{7}	1×10^{-5}
Tesla	1×10^{-4}	1	1×10^{-3}	1.5500×10^{3}	1	1.5500×10^{3}	1×10^{-9}
Millitesla	0.1	1×10^{3}	1	1.5500×10^{-4}	1×10^{3}	1.5500×10^{6}	1×10^{-6}
Weber/Inch^2	6.4516×10^{-5}	6.4516×10^{-4}	6.4516×10^{-2}		6.4516×10^{6}	1	6.4516×10^{-13}
Weber/Meter^2	1×10^{-4}	1	1×10^{-3}	1.5500×10^{3}	1	1.5500×10^{3}	1.0×10^{-9}
Line/Inch^2	6.4516×10^{-5}	6.4516×10^{-4}	6.4516×10^{-2}	1	6.4516×10^{6}	1	6.4516×10^{-13}
Gammas	1×10^{6}	1×10^{9}	1×10^{6}	1.5500×10^{12}	1×10^{9}	1.5500×10^{12}	1

SOME COMMON MAGNETIC MATERIALS

	B_DH_D-Peak Energy Product	(B_R)-Residual Induction Gauss	(H_C)-Coercive Force Oersteds
Barrium Ferrite	1.4×10^{6}	2450	2200
Ceramic	2.6×10^{6}	3350	2350
Alnico V	5.5×10^{6}	12800	640
Alnico VIII	6.0×10^{6}	9200	1550
Rare Earth	18.0×10^{6}	8600	8000

Glossary of terms

Bipolar sensor, magnetic — A Hall effect sensor that has a plus (South pole) maximum operate point, and a minus (North pole) minimum release point. Operate and release points can also be both positive or both negative. Therefore, **latching cannot be guaranteed.** Ring magnets are usually used with bipolar sensors.

Bipolar-latching sensor, magnetic — A true latching device. Guaranteed to switch on with positive gauss only and switch off with negative gauss only.

Current sinking output (NPN) — Load is connected between power supply and sensor. Current flows from the load through the sensor to ground (open collector).

Current sourcing output (PNP) — Load is connected between sensor and ground. Current flows from the sensor through the load to ground (open emitter).

Differential travel (D.T.) — Plunger or actuator travel from point where contacts "snap-over" to point where they "snap-back."

Flux concentrator — Any ferrous material positioned so as to concentrate magnetic flux in the sensing area, thereby increasing the flux density as seen by the Hall effect sensor.

Gauss — The CGS unit of flux density (magnetic induction).

Hall effect — The description given to the following phenomena: When a conductor through which a current is flowing is placed in a magnetic field, a difference in potential (Hall voltage) is generated between the two opposed edges of the conductor in the direction perpendicular to both the field and the current.

Hysteresis — The property of a digital Hall effect sensor where its operate point is different in value from its release point.

Linearity — The closeness of an actual curve to a specified straightline. The degree to which the output of a linear device deviates from ideal performance.

Linear output — An output which changes in proportion to the input.

Magnetoresistive effect — The change in the resistance of a semiconductor device in which the electrical resistance is a function of the applied magnetic field. A magnetoresistive element will respond to any magnetic fields (North **or** South pole) which are **parallel** to it.

North pole (magnetic) — The pole that is attracted to the geographical north pole, therby repelling the north seeking pole of a compass. Lines of flux are directed away from this pole.

Omnipolar sensor, magnetic - A sensor that operates with any magnetic field (North **or** South pole).

Operating force (O.F.) — Amount of force applied to switch plunger or actuator to cause contact "snap-over." Note in the case of adjustable actuators, the force is measured from the maximum length position of the lever.

Operating position (O.P.) — Position of switch plunger or actuator at which point contacts snap from normal to operated position. Note that in the case of flexible or adjustable actuators, the operating position is measured from the end of the lever or its maximum length. Location of operating position measurement shown on mounting dimension drawings.

Overtravel (O.T.) — Plunger or actuator travel safely available beyond operating position.

Pretravel (P.T.) — Distance or angle traveled in moving plunger or actuator from free position to operating position.

Ratiometric — The output voltage is proportional to the supply voltage in some set ratio.

Regulated Voltage — Desired output voltage is maintained regardless of normal change to input or output load.

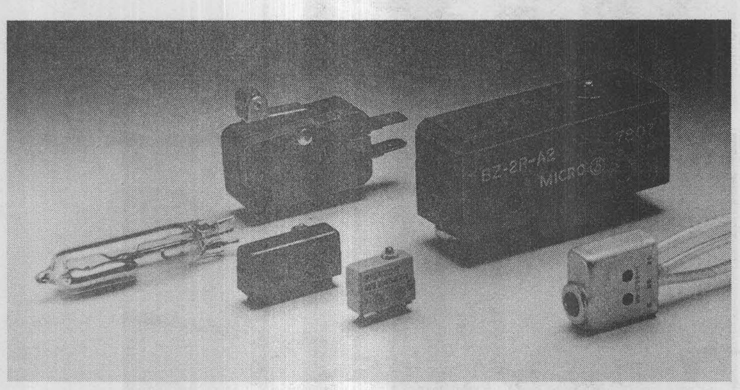
South pole (magnetic) — The pole that is repelled by the geographical north pole, and therefore attracts the north seeking pole of a compass. Lines of flux are directed toward this pole.

Unipolar sensor, magnetic — A Hall effect sensor that has a plus maximum operate point, and a plus minimum release point. One magnetic pole (South) is required to operate and release a unipolar sensor.

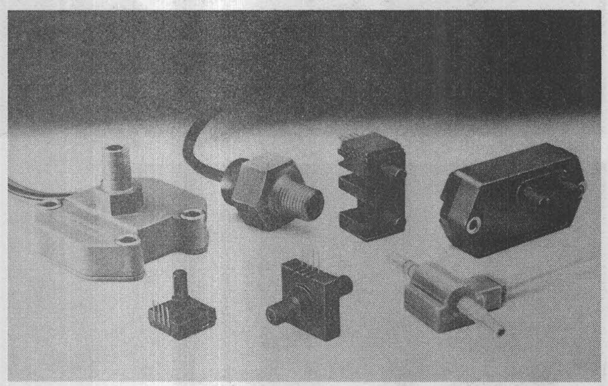
Other MICRO SWITCH products

MICRO SWITCH's reputation as an innovator in the design and manufacture of quality position sensing and manual control products spans 50 years. Shown is a cross-section of the many varieties. This broad selection offers a wide range of technologies, sizes, actuation means, circuitries, electrical capacities, and terminations, for in-plant and original equipment needs.

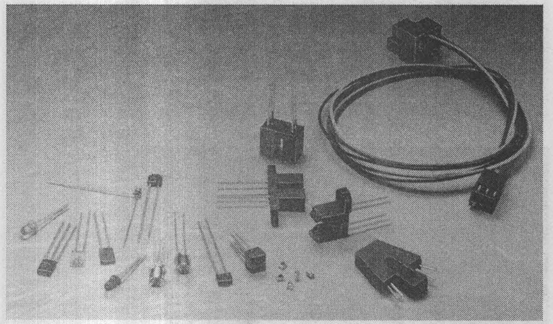
Contact your nearest MICRO SWITCH Sales Office or Authorized Distributor.



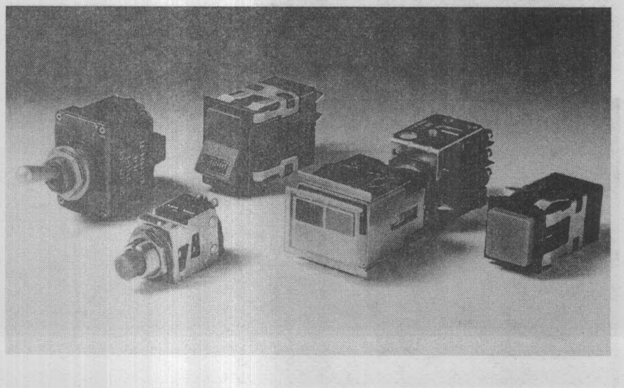
Basic switches
These listings include standard size basics, miniature, subminiature, hermetically sealed, high temperature and mercury switches. The precision snap-action mechanisms are offered with wide variety of actuators and operating characteristics. MICRO SWITCH basic switches are ideal for applications requiring compactness, light weight, accurate repeatability and long life.
Catalog 10



Solid state pressure sensors
MICRO SWITCH pressure sensors are small, low cost and reliable. They feature excellent repeatability, high accuracy, and reliability under varying environmental conditions. In addition, they feature highly consistent operating characteristics from one sensor to the next and interchangeability without recalibration.
Catalog 15



Optoelectric sensors
Optoelectronics is the integration of optical principles and semiconductor electronics. Optoelectronic components are reliable, cost effective sensors. Standard infrared emitting diodes (IREDs), sensors and assemblies are covered.
Catalog 25

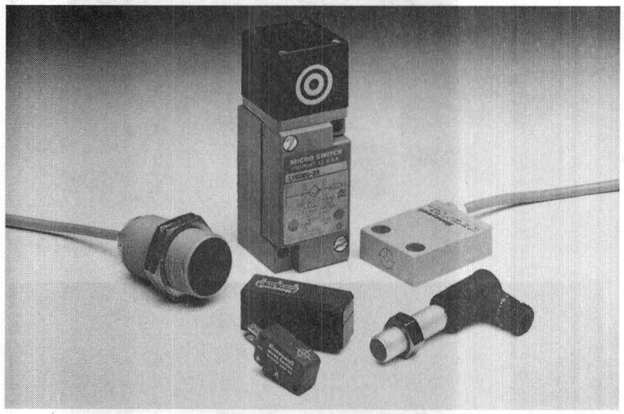


Manual control switches
Whether you're prototyping a new design or planning to face-lift an existing panel, you'll benefit by considering the wide selection of pushbuttons, indicators, toggles, rockers, paddles, rotary selectors and interlock switches available from MICRO SWITCH. Developed with adherence to good human factors principles, these products aid the designer by offering almost limitless options in visual display techniques, operators, and arrangement of components. Many are military qualified.
Catalog 30

Other MICRO SWITCH products

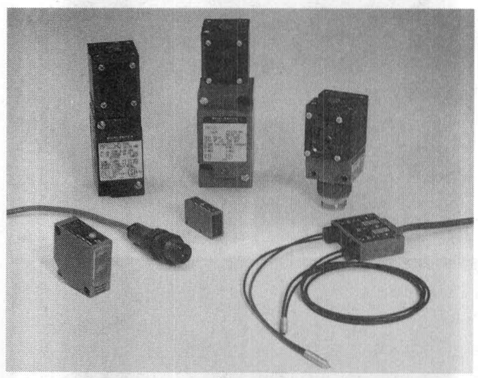
Limit and enclosed switches
MICRO SWITCH offers the world's most advanced line of heavy duty limit switches and a wide selection of application proven enclosed switches (precision snap-acting switches sealed in rugged metal housing). Sealed versions keep out moisture and other contaminants. Explosion-proof types are designed for use in hazardous locations.
Catalog 40

Proximity sensors
Proximity sensors detect the presence of metals or react to a magnetic field. Cylindrical, cannister, and limit switch style housings provide application versatility. Their high speed operation keeps pace with production. Models are available for operation at A.C. line voltage or wide range VDC. Optional LED indicators signal on-off conditions.
Catalog 50



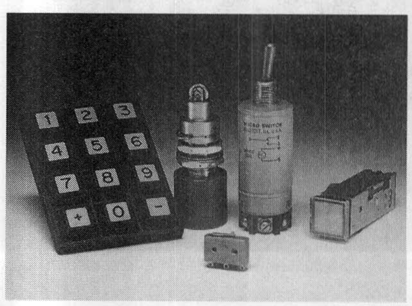
Photoelectric sensors
MICRO SWITCH has a complete offering of modulated LED and incandescent controls. These no-touch devices detect opaque or translucent material at long or short range.

Single unit retroreflective and separate emitter/receiver styles fill a variety of application requirements. High intensity models penetrate foggy, dusty, and other poor visibility conditions. Scanning capability ranges from a fraction of an inch to hundreds of feet.
Catalog 60

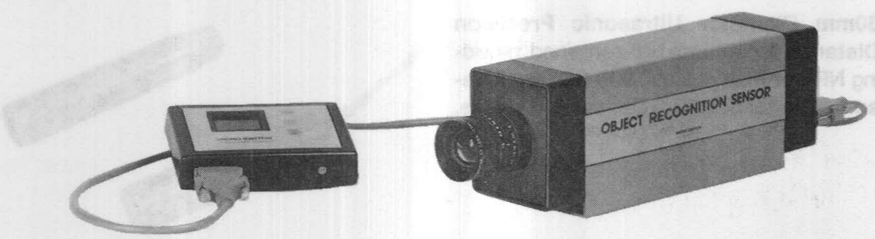


Oiltight manual controls
Featuring the contemporary square appearance and lighted display, these families offer a wide selection of industrial pushbuttons, selectors, and indicators. Standard, miniature, and compact sizes provide flexibility in format and circuitry. Contact blocks feature heavy duty, standard or electronic duty capabilities plus solid state.
Catalog 70

Environmentally protected switches
Rugged, high performance designs; environment-proof or hermetically sealed, a complete selection includes miniature limit switches, miniature and standard size basic switches, sealed toggle switches and the highest quality lighted pushbuttons.
Catalog 80

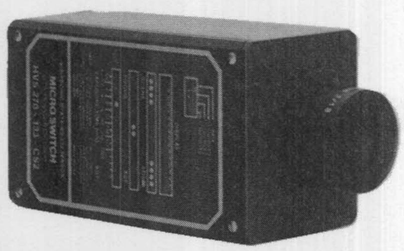


Other Sensors and Gauges



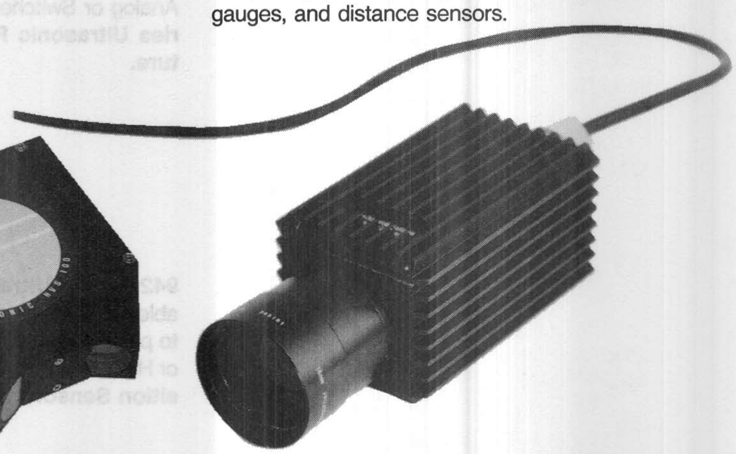
OBJECT RECOGNITION SENSOR
950RS Object Recognition Sensor scans parts and compares their image with a reference image preset in the sensor's memory. The sensor can detect subtle differences in size, shape or pattern, thereby making it ideal for part identification, orientation and inspection tasks. The sensor can analyze and compare up to 16 different objects at line speeds of 600 objects a minute. **ORS Series Literature.**

DISTANCE GAUGES/SENSORS
Exacting requirements for precision, high-speed position and distance measurement are met by precision edge/width or distance gauges, and distance sensors.

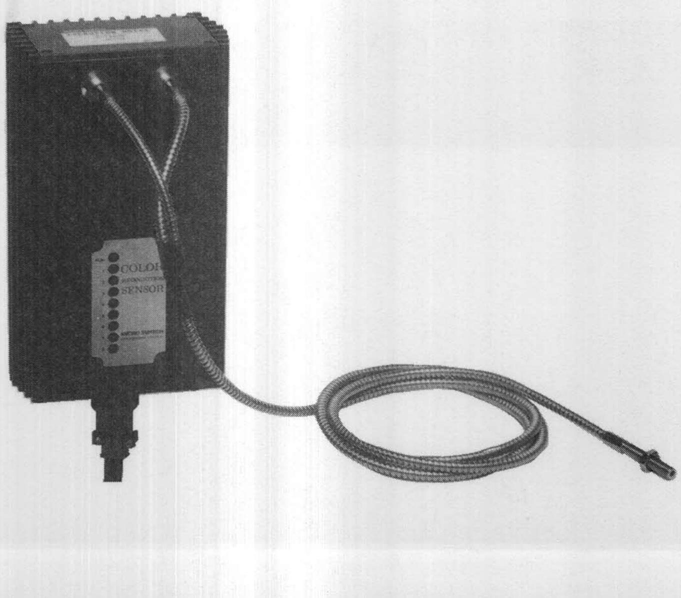


Edge/width gauges are used to detect an object's width, center or edge position. **HVS200 Family Literature.**

Distance gauges can measure material and coating thicknesses, indicate the depth of gaps and slots, detect miniscule surface wear, and enable accurate parts positioning for bonding, welding, and fastening. **HVS100 Series Literature.**



HVL Light Sources
MICRO SWITCH has the broadest line of industrial light sources available. There are six different types, each one has both a fixed and adjustable light output version. **HVS200 Family Literature.**

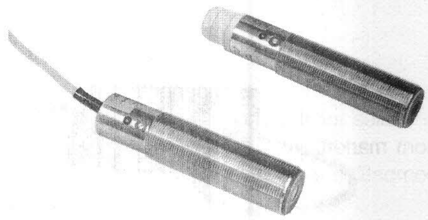


CRS301 COLOR SENSOR
The CRS301 Color Sensor is designed for the factory floor and can be trained to recognize 8 different colors or shades – online – at up to 5000 parts per minute. It covers the entire visible spectrum. Individual sink/source outputs can be used for external control or interfaced to a PLC. RS-232c and RS-485 communications ports allow use of an optical software interface package for simple menu-driven setup/analysis/output options. **Request information on the CRS301 Color Sensor.**

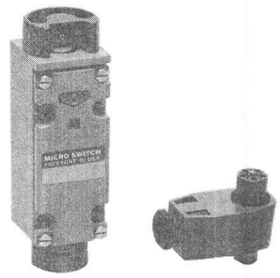
All-Materials Proximity Sensors

MICRO SWITCH All-Materials Proximity Sensors incorporate the latest developments in ultrasonic technology to detect whether or not an object is present at a pre-determined setpoint distance, without touching the target. These sensors have an acoustic transducer which vibrates at ultrasonic frequencies. Pulses are emitted in a cone-shaped beam and aimed at a target object. Pulses reflected by the target to the sensor are detected as echoes. The time delay between each emitted and echoed pulse is measured to accurately determine sensor-to-target distance, thus supplying background suppression.

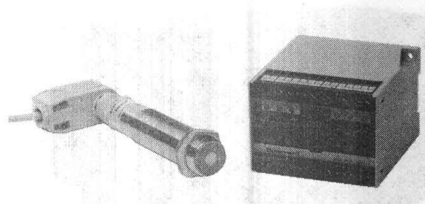
30mm Diameter Ultrasonic Precision Distance sensors are self-contained, providing NPN or PNP outputs. **940 Series Ultrasonic Digital Setpoint Sensor Literature.**



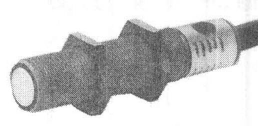
941 Series Ultrasonic sensors provide Analog or Switched digital outputs. **941 Series Ultrasonic Position Sensor Literature.**

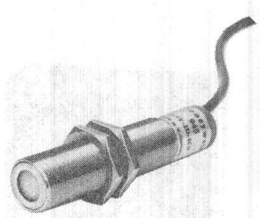


942 Series Ultrasonic sensors are available with a choice of three different amplifiers to provide Switching, Analog or Digital (BCD or Hex) outputs. **942 Series Ultrasonic Position Sensor Literature.**



945 Series Ultrasonic Position Sensors are only 18mm in diameter. Plastic housed sensors have fixed internal setpoint and external set-point adjustment. Stainless steel housed sensors feature analog output covering 100 to 600 mm sensing range.

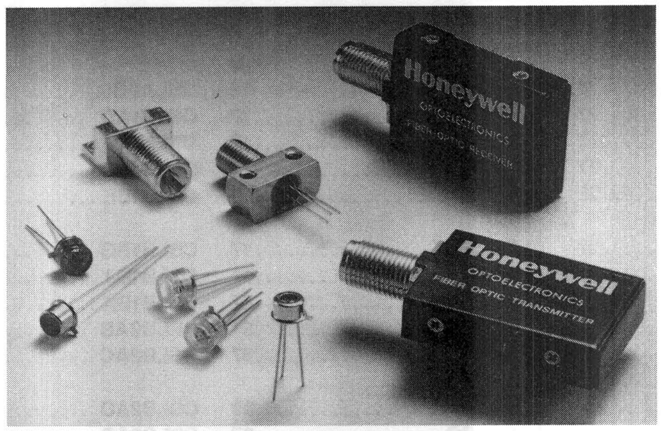




FIBER OPTICS

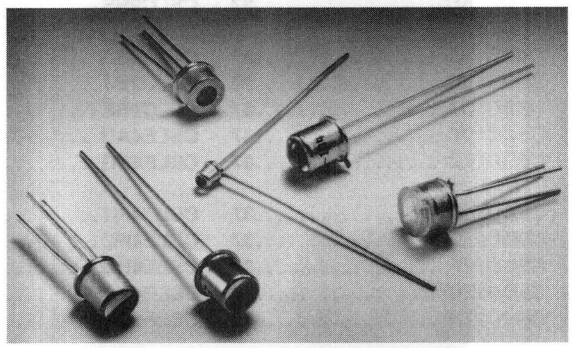
The Fiber Optics group specializes in the design, development and manufacture of active optoelectronic components and subassemblies for the short-haul fiber optic datacom market. Active fiber optic products are compatible with the majority of standard multimode fiber optic connectors and cables now available in industry.

Custom fiber optic products are also available. They are standard products with special testing, selection, documentation and/or minor physical changes to meet special requirements. New innovative products are constantly in development. **Request Fiber Optic Selection Guide**.



HIGH RELIABILITY PRODUCTS

Fiber optic and optoelectronic products from Honeywell have been used in many commercial and military applications. Many commercial components undergo additional testing in accordance with MIL-S-19500 for vibration, thermal shock, burn-in, constant acceleration and hermeticity. They can be designed for radiation hardened applications, qualifying them for use by defense contractors in their products. **Request High Reliability information.**



Alphabetical Product/Page Cross-Reference Index